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MULTIPURPOSE ELECTRIC FURNACE SYSTEM

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Final Report
NAS 8-30289

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Marshall Space Flight Center, Alabama

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ABSTRACT

A multipurpose electric furnace system of advanced design for space applications has been developed and tested. This system is intended for use in the Apollo-Soyuz Test Program. It consists of the furnace, control package and a helium package for rapid cooldown. The system meets or exceeds all the performance requirements of the contract.

1. INTRODUCTION

The Multipurpose Electric Furnace System (MEFS) designed and constructed for Skylab and designated as the M518 facility is an essentially self-contained unit requiring only power (approximately 28 V, DC), a vacuum line (capable of maintaining 10^{-3} torr or better in the furnace), and a heat sink (having a thermal impedance of approximately 0.65°C/watt). As a result, any facility capable of meeting these requirements can accommodate this furnace.

Although the MEFS on Skylab met all expectations of performance and reliability, it was apparent that improvement in function could be obtained with some quite specific modifications to parts of the system. Several areas for improvement were identified:

1. The furnace has the capability of operating at higher temperatures. With minor exceptions the materials used in construction are compatible with operation of heaters at approximately 1150°C. This temperature range permits the processing of many new materials that would otherwise be excluded because of temperature limits.

2. Unnecessary heat losses associated with specific assemblies were identified. Significant reduction of these losses would be accomplished by design changes that would have minor impact on construction but which would result in significantly improved performance and efficiency. This reduction in waste power would have a dual impact:

   a) experiments requiring higher temperatures could be performed at equivalent or less power than the M518, and
   b) a larger fraction of the available power could be directed toward doing useful work in the cartridges.

3. The M518 control was designed to provide a linear cooldown rate for samples requiring directional solidification. This results in a nonlinear interface growth velocity, the velocity increasing as solidification proceeds. As a result, only a fraction of the resolidified material experienced near-linear growth rates. The fraction of material that could be regrown at near-linear rates could be significantly increased in the cooldown rate followed a specific nonlinear function. This function could be incorporated with only minor impact on the existing control circuitry.

4. Although the possibility of having a shorted thermocouple must be considered as low, a mechanism for accommodating such a malfunction is desirable. With minor modifications to the control circuitry, this protection could be provided and increased system reliability and safety obtained.

5. The heat capacity of the furnace and its intrinsic efficiency limit the cooldown rate. If the heat loss mechanisms are reduced, the cooldown time is increased. This time becomes a limiting factor in the number of experiments that can be run in a given time. It is apparent that the efficiency of the insulation can be dramatically reduced by the introduction of a heat transfer medium such as helium. This modification necessarily requires the addition of new equipment -- a gas supply system. However, its addition results in a greatly increased utilization of the total MEFS system.

All the above modifications have been evaluated, designed, and constructed. Essentially, a new furnace was constructed within the M518 mockup provided, while the control package was the M518 qualification test unit and appropriate modifications were made to it to provide the new functions. The helium rapid cooldown system had no analog in the M518 system and a new unit was constructed. All

modifications were tested independently and the functions checked against the design goals. Each of the subsystems of the MEFS (furnace, controller, helium/rapid cooldown) were individually checked and evaluated relative to function and design criteria. A test set up was constructed and the total system was run and the performance evaluated. Extensive tests were run and test data compiled so as to verify the function of the incorporated modifications and to define the new system operating parameters. The tests were run in sufficient detail such as to provide a compilation of information suitable for incorporation into the development test report for the MA-010 MEFS.

While the goal of the program was specifically to design, construct and test modifications to an improved MEFS system, additional tasks were requested by MSFC during the course of the program. These included:

1. Evaluation and implementation of cartridge removal concepts consistent with an hermetic system.
2. Interaction with Rockwell International to assure compatibility of dimensions and requirements with the ASTP docking module.
3. Development of a simple thermal analytical model to describe the heat flow of MEFS.
4. Develop preliminary conceptual design of the experiment cartridges for the Principal Investigators to identify feasibility of the experiment performance in the MA-010 and to provide concepts for PI experiment development.
5. Make preliminary evaluation for the feasibility of designing and constructing a flight qualified pulser unit for experiment MA-060.
6. Attend review meetings with RI, MSFC, and JSC to identify any major incompatibilities that may exist between the MA-010 and the Docking Module design.

All aspects of the program were successfully completed.

2. DESIGN MODIFICATIONS AND PRE-DESIGN TESTS

The following sections treat in detail the modifications which were made to the Skylab M518 System in order to meet the requirements of the Apollo-Soyuz Test Program (ASTP). The changes which were made to the configurations of the Multipurpose Electric Furnace (MEF) and Control Package (CP) were relatively minor in scope, however, the performance of these two subsystems was significantly improved. In some instances predesign testing was performed to validate design concepts or material compatibility. Finally, a completely new subsystem, the Helium Package (HP), was designed to permit the rapid furnace cooldown necessary with the compressed ASTP time line.

2.1 Furnace Modifications

The design modifications of the MEF were prompted by two major considerations: the need for higher operating temperatures and the desire for reduced power requirements. The variety of materials experiments proposed for the ASTP mission require temperatures in excess of the $\sim$ 1000°C limit of the Skylab M518 system. Further, the reduced heat dissipation capability of the ASTP vehicles mandated that these higher temperatures be obtained with no increase in power requirements.

Experience with the M518 MEF suggested that somewhat higher temperature operation would be possible without any modification; however, the power requirements would be excessive. Therefore, the initial thrust of the re-design effort was to reduce the intrinsic heat loss. The predicted performance of the re-designed system was sufficiently

encouraging that even higher temperature operation appeared feasible if it were compatible with the furnace materials, especially the heating elements. Accordingly, the high temperature components of the furnace were carefully evaluated and where necessary, materials were changed or assembly techniques modified to provide reliable operation.

2.1.1 Intrinsic Heat Loss Reduction

a. Analysis of the M518 MEF indicated that one of the significant heat losses was the "piping" of radiation between the heat shields. This loss could be reduced by providing a "mitred" closure of the radiation shields at the colder as well as at the hotter end of the furnace. This type of construction would, in essence, provide a "nested can" shield configuration where the only radiation leaks occurred through the necessary clearance gaps in the shields. The efficiency of the shield system was also increased by using two interstitial shields of 0.0127 mm (0.0005 in.) thick molybdenum foil between adjacent main shields.

b. (Conductive Heat Losses). Conductive heat loss through the heat leveler support tubes was also reduced. In the M518 system, the heat leveler assembly was mechanically supported by three stainless steel (Type 310) gradient tubes 0.875 in. O.D. x 0.016 in. wall. These tubes had a combined thermal conductance of about 0.15 $W\text{-}cm\text{-}K^{-1}$ which would result in a conductive loss of about 21 watts with a furnace temperature of 1150°C. In the modified furnace, the wall thickness of the support tubes was cut to 0.008" which would reduce the loss by half.

2.1.2 Heater Elements

The design target maximum temperature of 1150°C for the MEF Heat Leveler mandated a re-examination of the heater elements. The first characteristic considered was the specific loading of the heater wires. This parameter controls the temperature difference between the wire itself and the work piece, e.g. the graphite heat leveler. If the

loading is too large, then the heater wire may be forced to run too hot in order to transfer the requisite power to the work. Several different variations of heater design were investigated including single and multiple ribbon heaters. It was found, however, that the double, non-inductive winding used for the M518 furnace was nearly optimum when the additional constraint of heater resistance was imposed. The specific loading of about 1 ω/cm^2 would impose a wire temperature only about 50°C greater than the heat leveler temperature.

The next factor investigated was the suitability of Kanthal A-1 as heater material. Although this material is suitable for use to 1325°C in air, at least one reference[1] does not recommend its use in vacuum at temperatures over 1000°C. This warning is founded in the rapid evaporation of a component (chromium?) from the alloy and verified by tests we performed on bare wires in ultra-high vacuum. Sample filaments burned out after two hours or less at a surface temperature of 1200°C. The heater winding, however, is NOT a bare wire operating in ultra-high vacuum.

A second test was performed with a Kanthal A-1 heater wound on a salvaged M518 heater form. In this geometry, the wire is completely surrounded by high purity alumina. In the test facility, this heater form was filled with a graphite block to simulate the heat leveler and heavily insulated with "Fiberfrax" to reduce heat losses. After 144 hours of operation, the windings were still operating; however, the heater resistances had changed a great deal. Examination of the disassembled unit revealed that evaporation of a volatile component had occurred and the wire itself was seriously degraded.

A further modification of the configuration was considered, namely, embedding the heater wires in high purity alumina cement. The life test was then repeated. The Kanthal was wound on the heater form and fired in air at 1000°C to form a surface oxide. A slurry of

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[1] Bockris, et al.

alumina powder (Morganite #961) was applied, air dried, and then fired at 1000°C. Finally, the test set-up was reassembled. After 100 hours of operation at $\sim$ 1200°C, the heater resistances had changed by only about 1.3%. Since the test time was roughly ten times larger than the anticipated operating requirements, this design was adopted for incorporation in the prototype furnace.

2.1.3 Suitability of High Temperature Materials

Coincident with the requirement of higher temperature operation of the modified furnace, it became necessary to evaluate the higher temperature suitability of the structural materials used in the Skylab furnace design. It was immediately obvious that the only portion of the design which might be doubtful was that part of the structure in close thermal proximity to the heating element. Furthermore, it was clear that the limiting condition was that of the combined effects of graphite, alumina and Type 310 stainless steel as they exist at higher temperature in the Multipurpose Furnace atmosphere and pressure environment. These materials, in the Skylab furnace design, are in direct physical contact.

In order to evaluate the limiting of this materials combination, a series of compatibility tests was carried out under conditions which approximated the Multipurpose Furnace environment. Alumina was promptly shown to be inert in these conditions at the intended temperature. The margin of safe temperature for the graphite-stainless steel combination, however, was found to be uncomfortably small. The intended maximum design temperature for graphite and stainless steel is 1150°C in the modified design. Our tests indicated that this materials combination exhibited no harmful degradation at 1225°C but degraded seriously at 1250°C. Thus, a furnace over-temperature of about 75°C would be allowable insofar as graphite and stainless steel reaction is a concern. While a margin of that value is probably adequate, it was desirable to provide a more comfortable choice of materials.

As a consequence, nickel was proposed as a replacement for the stainless steel and the graphite and nickel combination was evaluated. This combination exhibited no harmful degradation even at 1287°C, and it was deemed unnecessary to extend the evaluation to higher temperatures. The conclusion was that the graphite-nickel-alumina combination was safe to as least 1287°C and that the resulting over-temperature margin of 137°C was more than adequate. As a consequence, the modified Multipurpose Furnace design replaces Type 310 stainless steel with nickel in the temperature-critical areas.

2.1.4 Electrical Insulation of Thermocouples

With increased Multipurpose Furnace temperature a predictable consequence is increasingly-reduced thermocouple electrical isolation resistance. This occurrence is a natural property of the magnesia insulation in the prefabricated swaged thermocouples and has the effect of reducing the resistance between the Chromel-Alumel wires and the Inconel sheaths which, in the Skylab furnace, are electrically grounded to the furnace structure. This effect is acceptable at the 1000°C maximum temperature for which the Skylab furnace was designed. Because this effect is strongly temperature dependent, however, it becomes unacceptable at the higher (1150°C) maximum furnace temperature and, as a result, requires compensating design changes.

Greatly increased thermocouple resistance to ground was obtained by electrically insulating the Inconel sheaths from the grounded furnace structure. This was accomplished in the high temperature region by the installation of high purity alumina sleeves and in the low temperature region by Teflon sleeves. Additionally, the control thermocouple Inconel sheaths were electrically connected to the regulated 10 volt supply which biases the control thermocouples. This arrangement in effect applies a guard potential to the sheaths and thus eliminates the effect of the small remaining electrical leakage which exists with the insulating sleeves. The Inconel sheaths of the four measuring thermocouples are allowed to float electrically.

2.1.5 Modification of Access Port Seals

Experience disclosed that the seals of the access ports for the Skylab Multipurpose Electric Furnace were not suitable for repeated use because of the excessive force required for removal. No seal leakage was ever detected. Because rotating and reciprocating seals are used routinely in high vacuum systems, it appeared very likely that the fault with the Skylab furnace was not a fault of design principle but was rather more likely a fault of design detail dimensions. The O-Ring Handbook published by the Parker Seal Company was consulted as an up-to-date authoritative source closely related to both industrial and military applications. Information from this source was used as a guide for determining the design dimensions which were subsequently chosen for the modified seal design.

Analysis of the Skylab furnace seal design shows that it followed exactly the Parker recommendations for static vacuum seal applications (Design Chart 8-2). A static seal would normally be assembled and remain assembled rather than be repeatedly assembled and disassembled as in the case of the access port caps. Accordingly, the furnace design was modified to follow the Parker recommendation for dynamic vacuum seals (Design Chart 8-1). For vacuum applications Parker also suggests the use of O-rings in tandem as is already included in the furnace design. To further minimize the force required for access port cap removal, the modified access port bore is polished to a near mirror-like finish.

In order to verify the modified access port seal design, a simulated test fixture version of the modified access port assembly was built and tested. Obviously, the most stringent requirement was vacuum leak tightness. Mass spectrometer helium leak detector tests were unable to detect any leakage of the seal at 25°C and 120°C under static and dynamic conditions. The leak tests were repeated after hundreds of hours at 25°C and 120°C and after hundreds of mating and

separation cycles. On this basis, the prototype furnace was constructed according to the modified design. The experience with the prototype duplicates the experience with the test fixture.

As a back-up in the event the modified seals had been found to be inadequate, a radically new seal design was developed in conceptual form. The new concept was not developed in full detail, was not built, and is not recommended.

2.1.6 Pump Line Design

The M518 furnace was evacuated by evacuating the chamber in which it was situated. The MA-010 is evacuated through a pump line leading from the furnace through the DM wall to space. The furnace vacuum connection was redesigned to allow for this change. The M518 fitting was replaced by a one-inch diameter elbow terminating in a Gamah fitting which allows the furnace to be easily coupled to the DM pump line.

2.2 Helium Package

As used in Skylab, the Multipurpose Furnace was evacuated during the entire time period required for each experiment. The modified furnace, if evacuated, could require as much as twenty hours of passive cooling to reach the allowed touch temperature. For the ASTP mission, cooldown periods of such duration would seriously limit the number of experiments which could be fitted into the permitted time frame. In order to minimize this problem, a helium rapid cooldown system was developed. With this system the time required for cooldown can be reduced to as little as three hours.

Rapid cooling may be provided through selective control of the heat loss of the furnace. For minimum thermal transfer the heat shields described in 2.1.1 require a high vacuum environment, but the thermal transfer will be increased enormously if the vacuum environment is replaced by helium. Fortunately, only a very small amount of helium

is required for this purpose since the order of only 0.01 atmosphere approaches the maximum effectiveness. For the Multipurpose Furnace the volume required to produce 0.01 atm is roughly 0.16 cc He at standard conditions. Within the 0.01 atm range the thermal transfer is weakly dependent upon pressure, and it is consequently not necessary to provide a precise volumetric measure for each dosage. The Helium Package is designed such that successive doses of helium will be provided at slightly reduced volume.

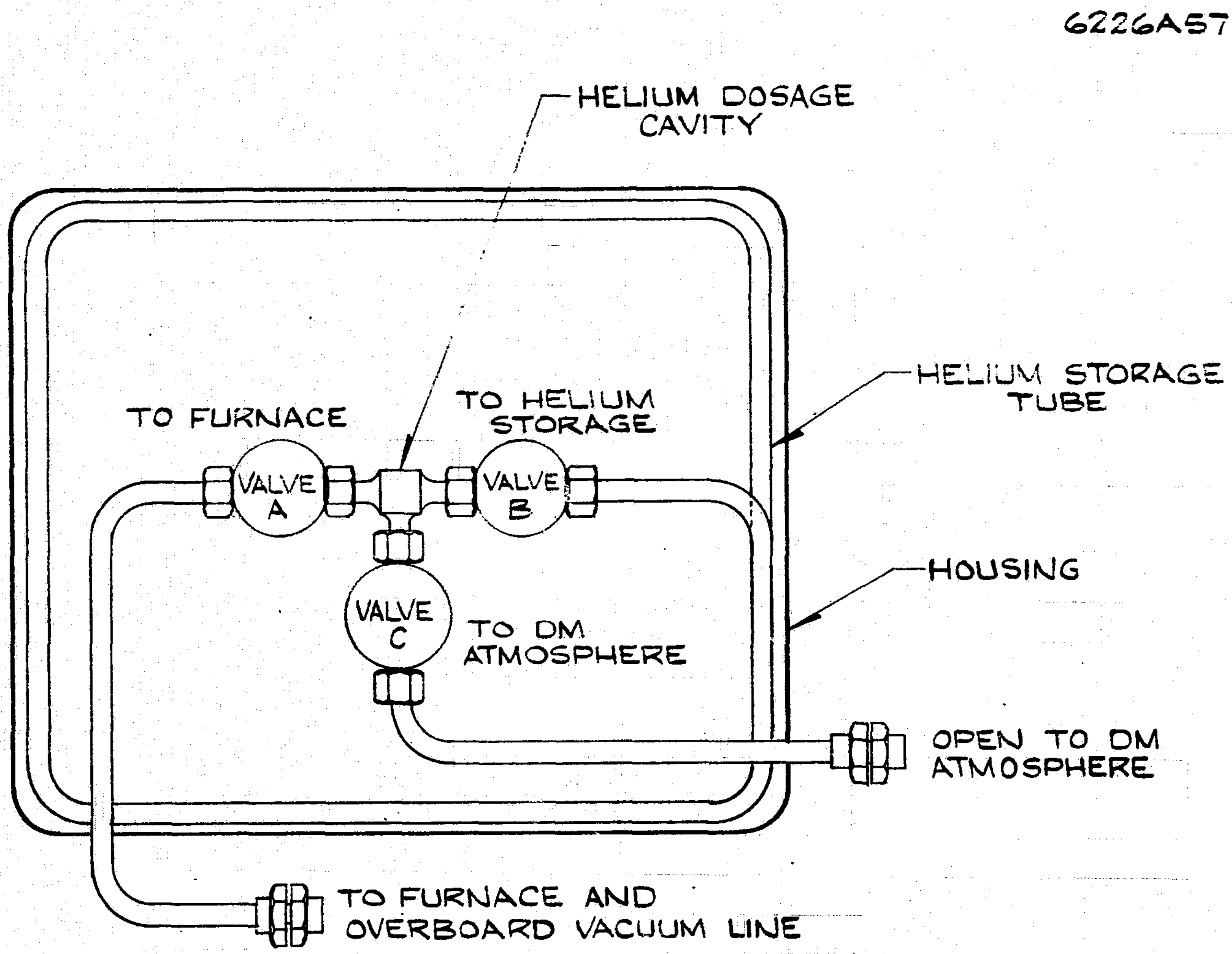
A schematic representation of the Helium Package (HP) is shown in Fig. 2-1. During each experiment prior to rapid cooldown, all HP valves must be closed. Immediately prior to operation of the HP, it is necessary to close the DM valve in the overboard vacuum line to the furnace. To initiate rapid cooldown two valve operations are required: (1) Valve B must be opened momentarily in order to pressurize the Helium Dosage Cavity from the Helium Storage Tube, and (2) Valve A must be opened momentarily in order to release the helium dosage into the furnace. No further valve manipulation is required during the rapid cooldown period.

When cooldown is completed and the allowed touch temperature has been reached, the experiment cycle is completed. Before the furnace may be opened, it should be pressurized to the same value as the Docking Module. This is accomplished with the HP by momentarily opening Valves A and C simultaneously and thus allowing the Docking Module atmosphere to flow into the furnace until the pressure is equilibrated.

2.3 Control Package

2.3.1 Introduction

The Control Package for the Multipurpose Electric Furnace System has been modified to meet a new set of requirements for the ASTP mission. These modifications include several changes of the system



HELIUM PACKAGE

SCHEMATIC REPRESENTATION OF HELIUM RAPID COOLDOWN SYSTEM

Fig. 2-1

operating functions and also mechanical modifications to meet new interface requirements. A listing of these modifications and a brief description of each is presented below. In addition to these items, a number of minor electronic component changes have been made to provide additional safety margins in circuitry operation.

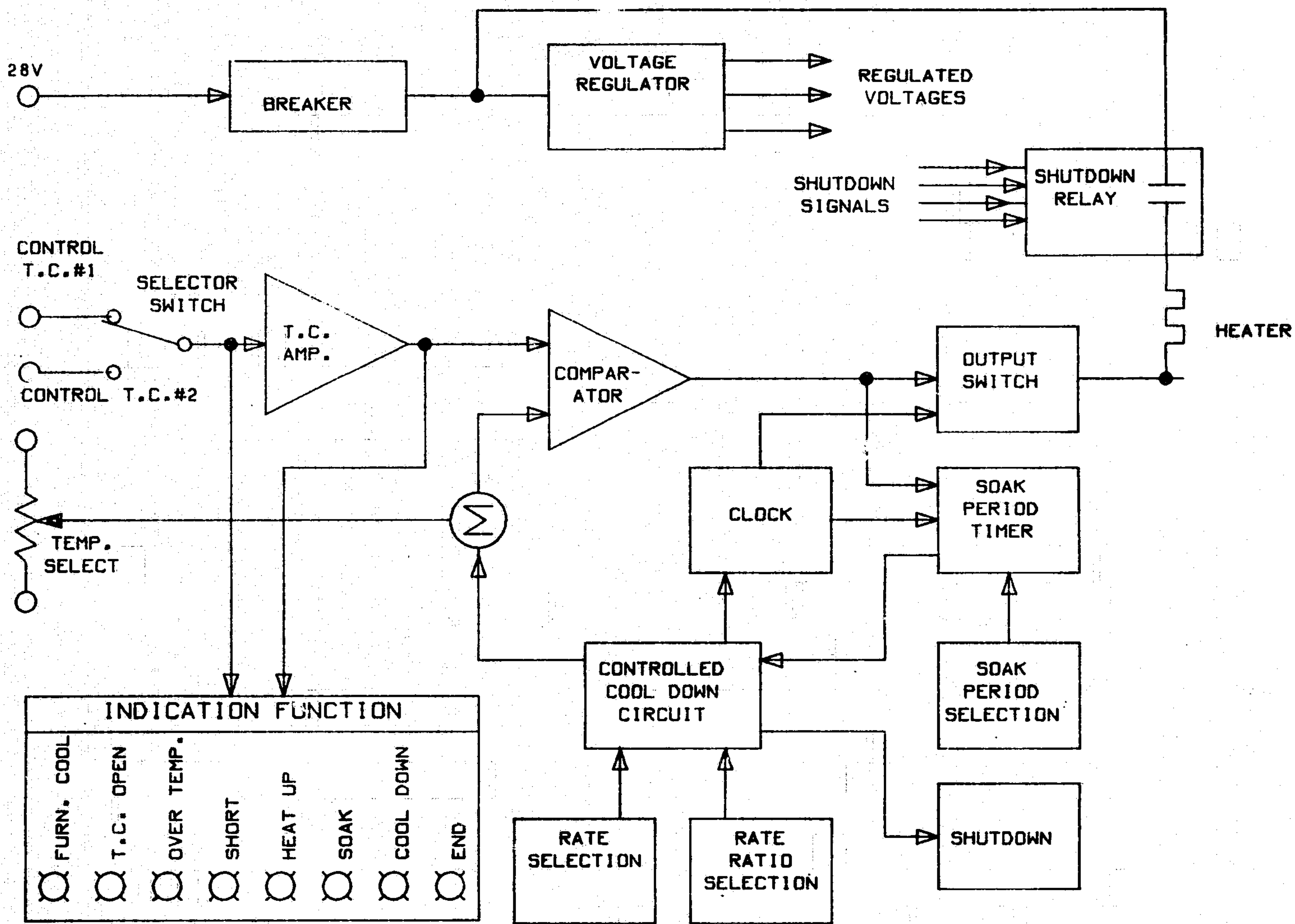
1. Increase Maximum Control Temperature -- To facilitate higher temperature experiments, the gain of the control thermocouple amplifier has been altered to permit a maximum controlled heat leveler temperature in excess of 1150°C.

2. Variable Controlled Cooldown Rate -- To provide more constant solidification velocities in the experiments, circuitry has been incorporated to continuously decrease the cooldown rate during the controlled cooldown portion of the experiment. A control is provided to enable selection of the amount of cooldown rate variation.

3. Shorted Control Thermocouple Protection -- To protect the furnace from overheating should the control thermocouple become shorted, an additional shutdown circuit has been incorporated in the control package. This circuit continuously monitors both HOT-1 and HOT-2 measuring thermocouples and automatically shuts off the furnace heaters if either of these thermocouples exceeds a preset limit temperature (nominally set at 1190°C).

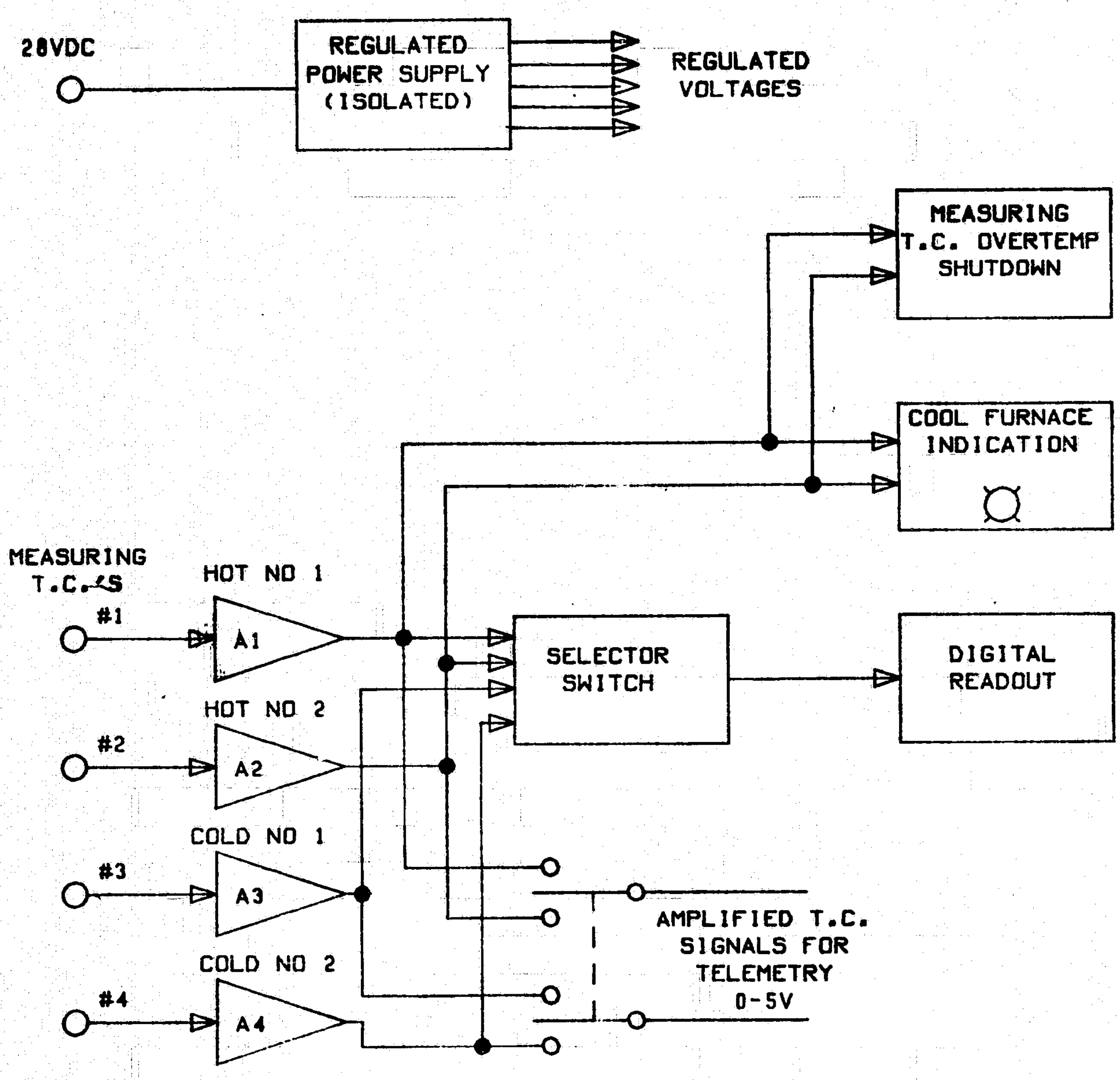
4. Mechanical Interface Modifications -- A new mounting mechanism and a new control cable between the control package and furnace have been designed to facilitate the ASTP system configuration. The input power and telemetry cable is being provided by RIC.

The operation of the ASTP Control Package is very similar to the operation of the M518 Control Package. The block diagrams for the two systems are therefore very much the same except for the introduction of the new control functions. The changes are easily identified with reference to the block diagrams shown in Figs. 2-2 and 2-3. In



FURNACE CONTROL SYSTEM

Fig. 2-2



THERMOCOUPLE MEASURING AND READOUT

Fig. 2-3

the Furnace Control System block diagram, the "rate ratio selection" is identified as a new input to the controlled cooldown circuit. The "measuring T.C. overtemperature shutdown function" identified in Fig. 2-3 provides the shorted controlled thermocouple protection function. The output of this shutdown circuit provides one of the shutdown signals to the "shutdown relay" shown in Fig. 2-2. All the other functions identified in these figures are the same as those for the M518 system.

2.3.2 Description of Circuitry Modifications

The new system control functions and modifications have been implemented by the addition of a new auxiliary control board, a number of modifications to the main control board, some modification of the control package wiring, and the replacement of two heater selector switches with a control potentiometer on the control panel. Circuitry on the auxiliary control board provides the new functions of "variable controlled cooldown rate" and the "shorted control thermocouple protection". Modifications on the main control board are component value changes and the addition of connection leads to the auxiliary control board.

2.3.2.1 Main Control Board Modifications

Let us first consider the modifications that have been made to the control board. A schematic of this board is shown in Fig. 2-4. The gain of the thermocouple amplifier (A3) has been changed to enable a maximum control temperature (at the furnace heaters) of 1180°C. To accomplish this, resistor R6 has been increased to 445 Ω to reduce A3 gain to give a nominal output voltage of +15 V (+5.00 volts referenced to the +10 V supply voltage) for an input thermocouple voltage of 48.09 mV (corresponding to 1180°C). Resistor R7 has been increased to 2.32 K to maintain a balanced input to A3.

The introduction of the variable cooldown rate function also has required several changes on the main control board. This new

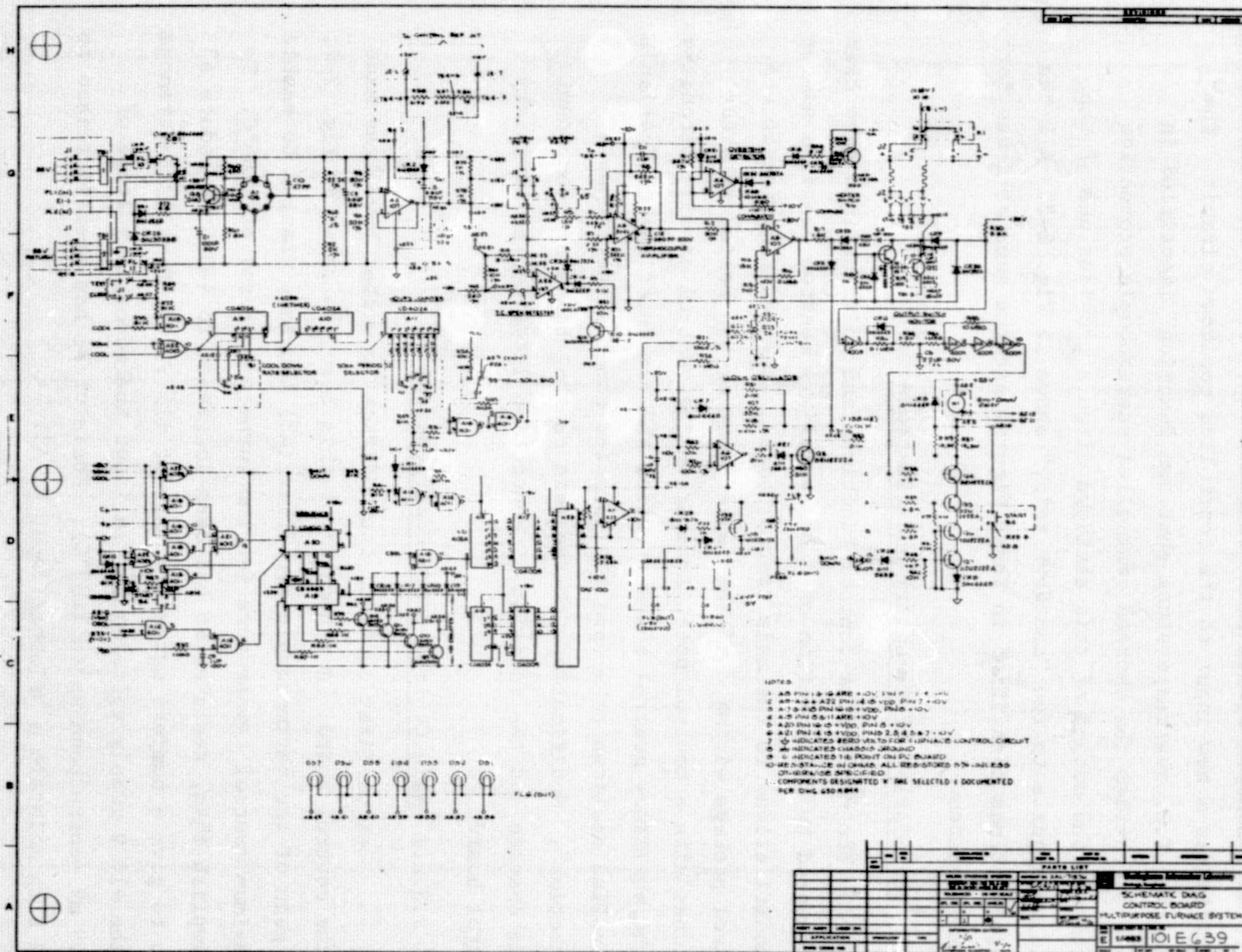


Fig. 2-4

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function is being implemented by automatically changing the internal clock rate during the controlled cooldown mode of operation. The internal clock rate of the CP is set by the "Clock Oscillator" circuit comprised of capacitor C6, amplifier A5, transistor Q3, and associated resistors and diodes. The clock rate is determined by the rate of charging and discharging C6 each clock period. For the M518 control package, a precision resistor across pins CE102 and CE103 was used to set the rate of charging C6. This precision resistor has been replaced by a circuit on the new auxiliary control board providing a controlled charging current to C6. During the controlled cooldown mode of operation, the charging current generated by this new circuit gradually decreases to cause the clock rate to decrease accordingly. As the clock rate decreases, the repetition rate of the clock pulses to the cooldown circuit decreases which increases the period between incremental steps out of the D/A converter (A23). Thus, the cooldown rate is decreased. A more detailed description of this "current source" circuitry is given later.

Resistor R21 has been changed in value and the wiring of counter stage A9 and cooldown selector switch S1 have been changed in conjunction with the new controlled cooldown function. Resistor R21 has been changed to 156 K, to provide a nominal controlled cooldown temperature for 150°C below the soak temperature (i.e., the cooldown rate is controlled by the CP until the furnace temperature drops 150°C below the soak temperature). This temperature range has been changed from 300°C to 150°C to reduce the time required for each experiment and to ease the problems of time scheduling each experiment. The wiring changes to counter A9 and switch S1 maintains the initial controlled cooldown rates of 0.5, 1.2, and 2.4°C/min that were available for the M518 series of experiments.

Other changes on the main control board include:

(1) addition of a wire connection (AE105) common with AE41 to permit exitation of the overtemperature caution light by the new overtemperature protection circuit (see section 2.2.2), and

(2) changing of resistor values to provide additional drive to relay K1. This latter modification is provided by changing the values of resistors R38, R39, R40, R43, R37, and R89 to those shown on the schematic.

2.3.2.2 Auxiliary Control Board Description

The auxiliary control board shown in Fig. 2-5 provides the functions of variable cooldown rate and protection against a shorted control thermocouple. Let us consider the variable controlled cooldown rate function first. This function is provided by resistors R11, R12, R13, R14, R15, R101, diode CR5, and transistor Q1 in conjunction with the clock oscillator circuitry described in section 2.2.1. The output of this circuit is a controlled current from the collector of Q1 (GE4) that sets the clock rate of the control package. The input to this circuit is the output of the D/A converter (A7 on the control board) through potentiometer R101 (10 K, 10 turn) mounted on the front panel. The charging current at the collector of Q1 is determined by the voltage across resistors R14 and R15. This voltage is nominally 3.3 volts during "heat up" and "soak" modes of operation. During the "controlled cooldown" mode of operation, the voltage at the output of A7 (i.e., AE101) increases. This causes the voltage at GE3 to increase and the voltage across resistors R11 and R14-R15 to decrease accordingly. The amount the voltage across R14-R15 decreases as a function of the setting of R101 and the voltage at AE101, the end result being a steady decrease in C6 charging current generated by this circuit throughout the controlled cooldown mode of operation. Test results of this function are presented later in this report.

The "shorted control T.C. protection" circuit is comprised of A1, A2, A3, A4, K2 and associated components. In reality, this circuit is a "measuring thermocouple overtemperature shutdown" circuit that shuts off power to the heaters should either HOT-1 or HOT-2 thermocouples exceed 1190°C. The inputs to the circuit are the amplified

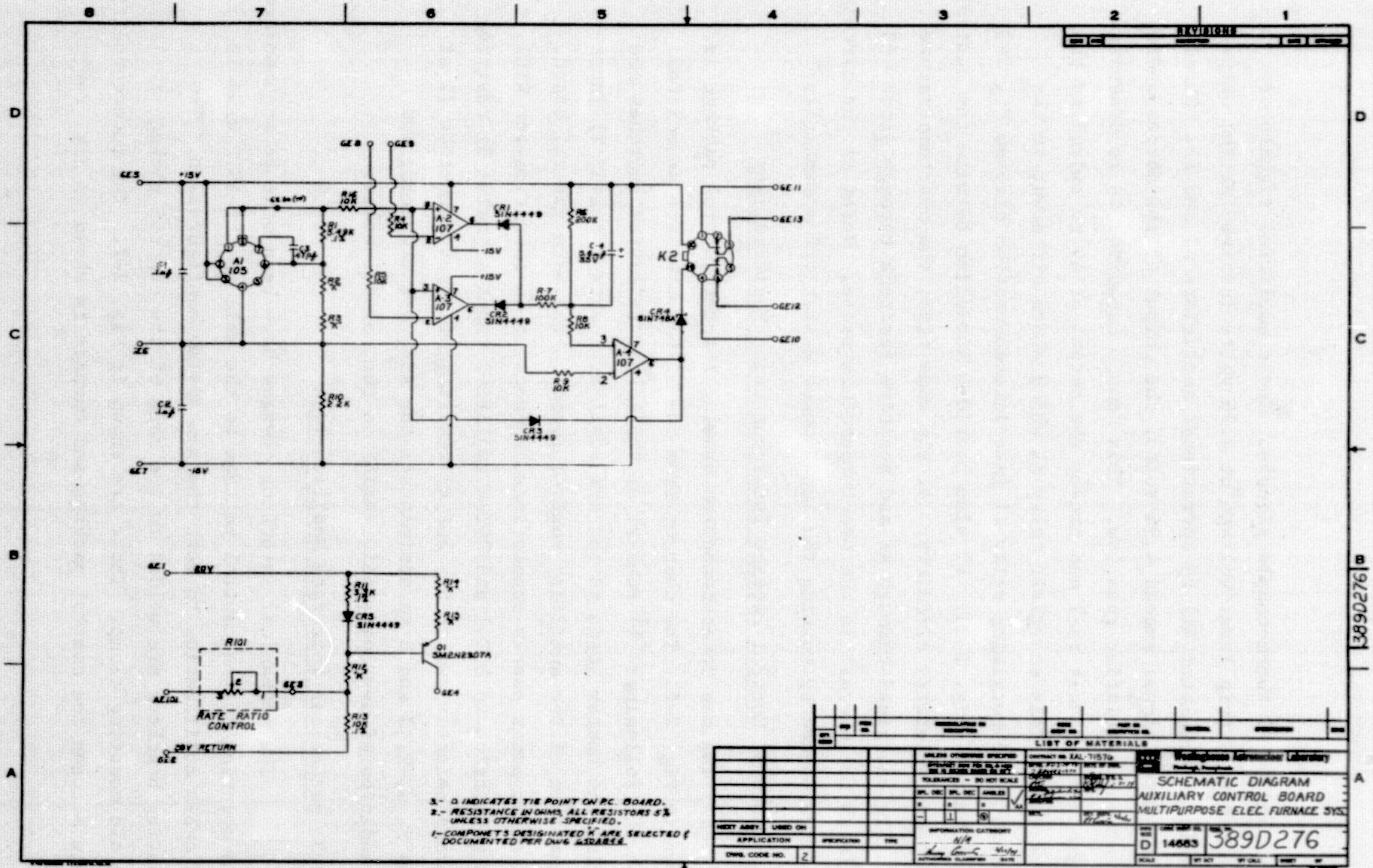

REVISIONS
+15V
-15V
-15V
28V
28V RETURN
A1
105
A-2
107
A-3
107
A-4
107
K2
CR1
SIN4449
CR2
SIN4449
CR3
SIN4449
CR5
SIN4449
R4
10K
R6
200K
R7
100K
R8
10K
R9
10K
R10
2.2K
R14
10K
Q1
SM2N2907A
R101
RATE RATIO
CONTROL
3.- ◻ INDICATES TIE POINT ON P.C. BOARD.
2.- RESISTANCE IN OHMS, ALL RESISTORS 5% UNLESS OTHERWISE SPECIFIED.
1.- COMPONETS DESIGNATED 'K' ARE SELECTED & DOCUMENTED PER DWG
LIST OF MATERIALS
NEXT ASSY
USED ON
APPLICATION
DWG. CODE NO.
INFORMATION CATEGORY
N/A
Westinghouse Astronuclear Laboratory
SCHEMATIC DIAGRAM
AUXILIARY CONTROL BOARD
MULTIPURPOSE ELEC. FURNACE SYS.
D
14683
389D276

Fig. 2-5

HOT-1 and HOT-2 thermocouple signals. These amplified signals are compared to a trip level voltage of 4.96 volts (derived at the output of voltage regulator A1) by operational amplifiers A2 and A3. Should either input signal exceed 4.96 volts, the output of the corresponding operational amplifier goes low. This causes capacitor C4 to discharge toward the -15 volt rail and causes the output of A4 to switch to the -15 V rail. This energizes relay K2 which shuts off power to the heaters by deenergizing relay K1 (see interconnection diagram Fig. 2-5 and schematic Fig. 2-3). K2 also provides isolation between the control board and telemetry circuitry. At the same time, the overtemperature light is energized through K1 and positive feedback through diode CR3 to latch the circuit in the overtemperature state. Reset of the circuit is accomplished by turning the input power switch off momentarily.

2.3.2.3 Control Package Interconnection Modifications

The new interconnection drawing for the control package is shown in Fig. 2-6. The changes from the M518 system are associated with the following: 1) removal of the heater selection switches and wiring the heater leads to the new auxiliary control board; 2) interconnection of the auxiliary control board to the main control board, K2 relay, power supply connections, connection to potentiometer R101, and connection to HOT-1 and HOT-2 amplified input signals; 3) rewiring of rate selector switch S1; and 4) rewiring of input connector J1 at pins F, G, T, J and H to accommodate the ASTP requirements; and 5) addition of new leads AE101-AE105 to the control board.

2.3.3 Mechanical Interface Modifications

The mechanical interface changes have been made to accommodate hard mounting of the control package to the wall of the ASTP vehicle and cable modification to meet the new system configuration. Two mounting brackets are welded to the base of the control package replacing the old mounting clamp. These are shown in Fig. 2-7. The interconnection cable between the control package and furnace is shown in Fig. 2-8.

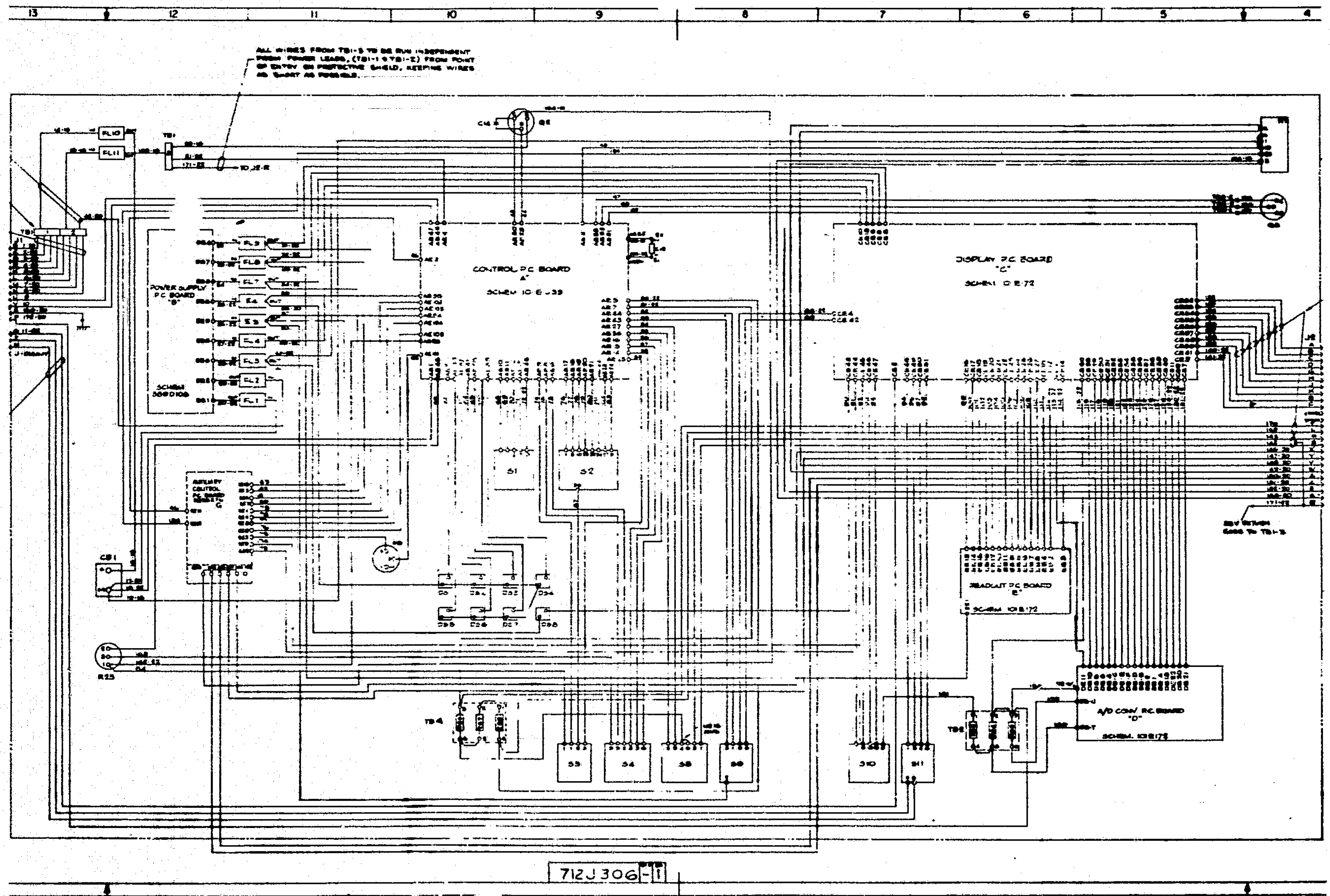
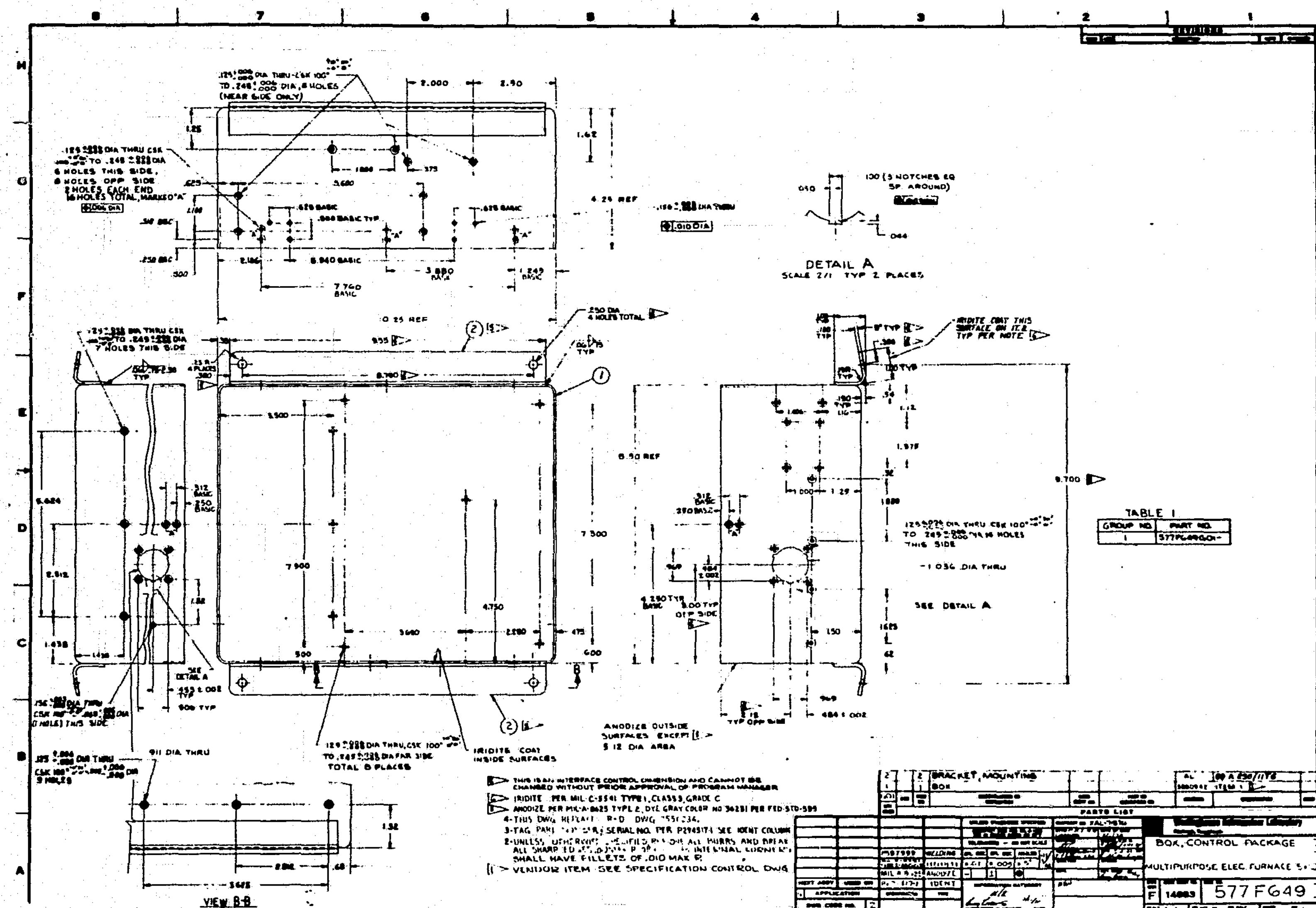

ALL WIRES FROM TB1-3 TO BE RUN INDEPENDENT FROM POWER LEADS, (TB1-1 & TB1-2) FROM POINT OF ENTRY ON PROTECTIVE SHIELD, KEEPING WIRES AS SHORT AS POSSIBLE.
CONTROL P.C BOARD "A"
DISPLAY P.C BOARD "C"
POWER SUPPLY P.C BOARD "B"
READOUT P.C BOARD "E"
A/D CONV P.C. BOARD "D"
712J306-1

Fig. 2-6



DETAIL A
SCALE 2/1 TYP 2 PLACES
TABLE I
GROUP NO. | PART NO.
SEE DETAIL A
IRIDITE COAT INSIDE SURFACES
ANODIZE OUTSIDE SURFACES EXCEPT
5.12 DIA AREA
TOTAL 8 PLACES
911 DIA THRU
VIEW B-B
BRACKET, MOUNTING
BOX
PARTS LIST
BOX, CONTROL PACKAGE
MULTIPURPOSE ELEC. FURNACE
14883
577F649

Fig. 2-7

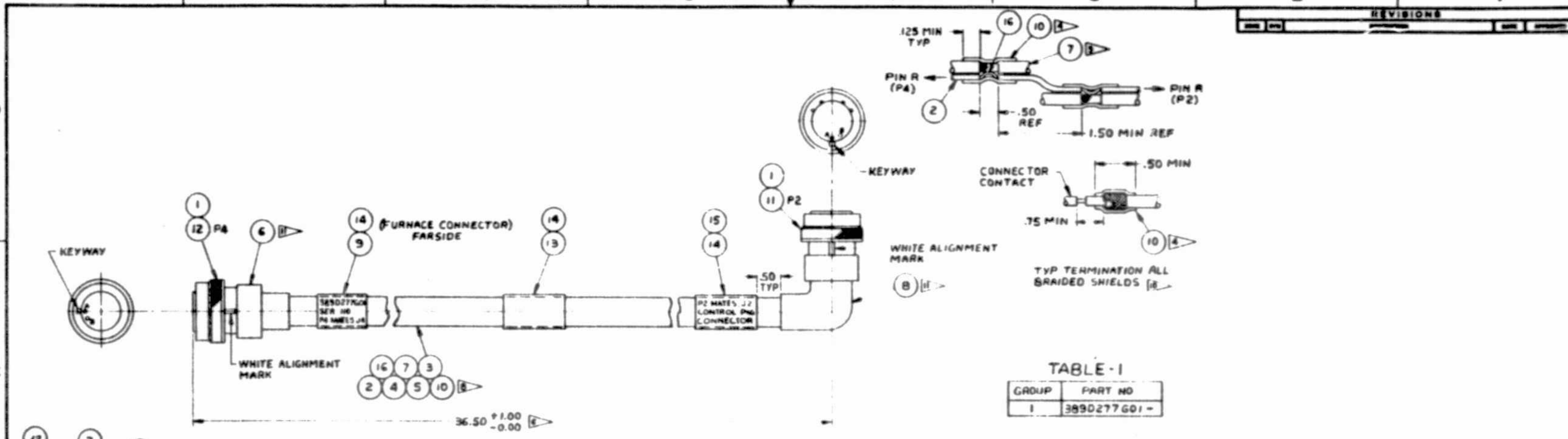
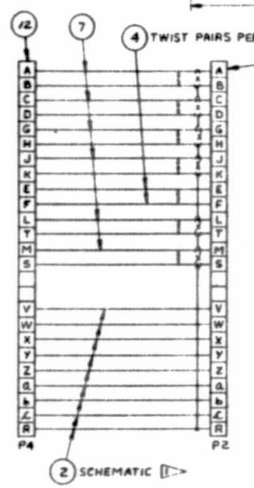


TABLE-1

GROUP	PART NO
1	389D277G01-



11. TORQUE CONNECTORS ITEMS 6 & 8 HAND TIGHT.
10. STAGGER TERMINATIONS AS REQD TO ACHIEVE MIN BUNDLE DIA
9. STRIP A .50±.25 LENGTH FROM THE JACKET OF THE SHIELDED PAIR & FROM THE ADJACENT PORTION OF THE SHIELD JUMPER WIRE. PREPARE ALL SHIELDED PAIRS, STAGGERING THE SPLICES BY A MIN OF 1.50 INCHES.
8. INSULATE SOLDER JUNCTION OF SHIELDS AND JUMPER WIRE SHIELD TERMINATION WITH ITEM 10
7- ACCEPTANCE TEST PER APPLICABLE PORTIONS OF TME 1893
6- SHIELD TERMINATIONS PER MSFC-STD-40M39582, CLASS 2, FIG. 3 REF
5. DRILL $.062^{+.006}_{-.000}$ DIA HOLE AT CENTER OF ITEM 3 ONE SIDE ONLY, PRIOR TO ASSY.
4. INSTALL PER MSFC-PROC-273.
3. DIMENSIONS, CONNECTORS & TERMINATIONS ARE INTERFACE CONTROL REQUIREMENTS & CANNOT BE CHANGED WITHOUT PRIOR APPROVAL OF PROGRAM MANAGER.
2. ASSEMBLY TO CONFORM TO QUALITY WORKMANSHIP STANDARDS MANUAL WANL-QWS-1 (WESTINGHOUSE ASTRONUCLEAR LAB)
1. SOURCE CONTROL DWG SEE VENDOR PART NO.
1. SECURE HARNESS WITH ITEM 5 PER 40M39582 STYLE A.

LIST OF MATERIALS

QTY REQD G01	SYM	ITEM NO	NOMENCLATURE OR DESCRIPTION	CODE IDENT NO	PART OR IDENTIFYING NO.	MATERIAL	SPECIFICATION	ZONE
AR		16	SOLDER		TYP RA	60SN	QQ-S-571	
1		15	IDENT TAG		800C905G05A			
AR	14	14	LACING TAPE				MIL-T-43435 TYPE 4 FIN D	
1		13	IDENT TAG		800C925G02-			
1		12	PLUG CONN.		389D211G06A			
1		11	PLUG CONN.		389D211G05A			
AR	8, 4	10	TUBING, HEAT REACTIVE	14981	276-2-1A-T-006301A		MSFC-SPEC-276	
1		9	IDENT TAG		800C925G01-			
1	2	8	ELBOW		389D118H01-			
AR		7	CABLE-22 AWG 2WIRE SHIELDED	14981	V6N22N2NA		40M39526	
1		6	ADAPTOR CONNECTOR	14981	569-15-0-16-16-1		40M51284/9	
AR		5	SLEEVING BRAID	14981	NGS-482-16			
AR		4	WIRE 22 AWG, NATURAL-TEFLON	14981	VCN22N		40M39513 B/S	
AR	5	3	TUBING	14981	40M51284-ST-16			
AR		2	WIRE-20 AWG, NATURAL-TEFLON	14981	V6N20N		40M39513 B/S	
2		1	CAP, PROTECTIVE		800C846G048			

UNLESS OTHERWISE SPECIFIED
TOLERANCES - DO NOT SCALE
CONTRACT NO XAL-71576

Westinghouse Astronuclear Laboratory
Pittsburgh, Pennsylvania

CABLE ASSEMBLY
MULTIPURPOSE ELEC. FURNACE SYS

PS38001	PACKAGING
	ACCEPTANCE TEST
P294520-1	CLEANING
P294517-1	IDENT
SPECIFICATION	TYPE

NEXT ASSY | USED ON | G APPLICATION | DWG CODE NO 2

INFORMATION CATEGORY

SIZE D | CODE IDENT NO 14683 | DWG NO 389D277
SCALE NTS | SHEET 1 OF 1

Fig. 2-8

This cable has been shortened to meet the new requirements and the vacuum cleaner feedthrough assembly has been removed since it no longer is applicable. The input power and telemetry cable is not shown since it is now the responsibility of Rockwell International Corporation.

3. DEVELOPMENT TEST PROGRAM: SUBSYSTEMS

Three main goals were envisaged for the development test program on the subsystem level:

* Comparison of the MA-010 subsystems with the design criteria;
* Evaluation of the stability of the subsystem characteristics;
* Determination of values for parameters in analytic models of the subsystems.

Each subsystem of the MA-010 system was therefore evaluated and characterized separately. Furnace power-temperature characteristics were evaluated under well-defined laboratory conditions. The control package performance was determined in detail using simulated thermocouple inputs. Finally, the helium package was tested; however, because of the nature of its operation, determination of its performance required operation in conjunction with the Multipurpose Electric Furnace.

3.1 Development Test Program: Multipurpose Electric Furnace

The primary goal of the MEF development test program was to verify that the furnace would operate at a sufficiently high temperature with acceptably low power consumption for the required time period. A subsidiary goal of the testing was to provide empirical values for the parameters in a simple, three node, thermal analysis model of the furnace. One additional task was added as the program developed: the pump-down characteristics of the furnace needed to be characterized in order to completely specify the MA-010 interface with the Docking Module being built by Rockwell International Space Division.

All testing was performed using the heat sink configuration shown in Fig. 3-1. For the initial tests, the heat sink was mounted in

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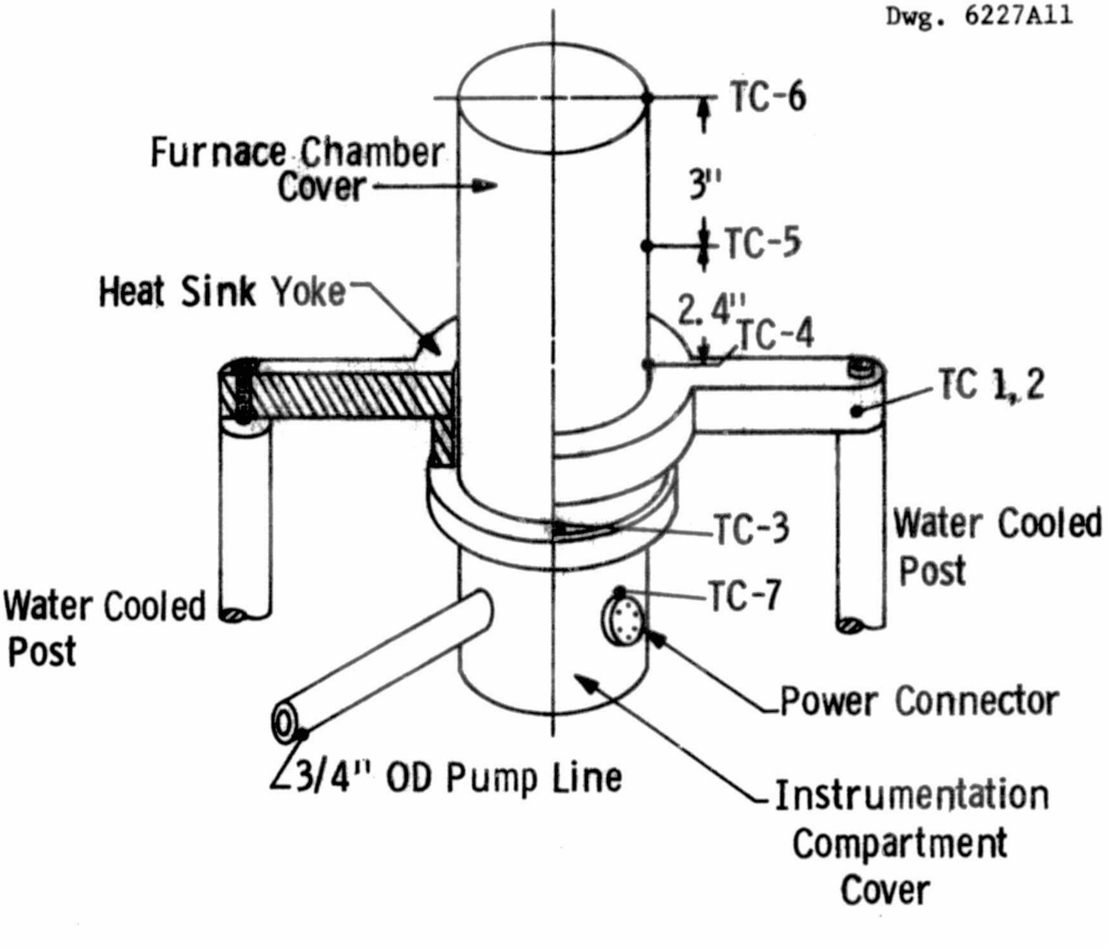

Fig.3-1–Furnace Test Configuration

a vacuum bell jar which also served to evacuate the furnace. Most of the tests, however, were performed with the furnace mounted in a bell jar which only served to control the external ambient; the furnace was evacuated by a separate system through the pumping line shown in the figure. Although the external ambient could be maintained at any pressure from atmospheric to high vacuum, the actual testing was done with high vacuum ($< 10^{-5}$ torr) to ensure that heat transfer from the furnace can was dominated by radiation.

For the testing of the MEF as a subsystem, heater power was supplied by a regulated DC power supply. Individual heater currents were measured using precision calibrated shunts and a L&N K-3 potentiometer which provided 0.01 percent accuracy in the current values. The heater voltages were measured at connection points inside the furnace instrumentation compartment so that no errors were introduced by voltage drops in the leads. A digital electronic voltmeter provided four digit accuracy in the voltage measurements, so that the overall accuracy in the power measurements should have been better than 0.1 percent. This precision was not realized in the earliest measurements because of ground loops and thermal EMF's in the measurement circuitry. Once these problems were recognized and eliminated, consistantly reliable measurements of the input power and system temperatures were made to high precision. The high precision of voltage and current measurements also permitted precise monitoring of the heater resistances during the entire test program.

Since one goal of the test program was to evaluate the parameters in a thermal model, it was necessary to measure the various power fluxes in the system, especially the power flux into the heat sink. This was accomplished with the test facility by measuring the temperature drops in the heat sink yoke (see Fig. 3-1) as a function of power using an independent heat source instead of the furnace. This device consisted of a stainless steel plate and heating element which mated with the heat sink. Radiation shielding and insulation was incorporated in a manner so that essentially all the input power to

the heating element was dissipated through the heat sink. In this fashion, the heat flux through the heat sink could be determined by measuring the temperature drops between TC3 and TC's 1 and 2. Since some power is radiated from the collar and arms of the heat sink yoke, this calibration was temperature dependent and this correction was made in evaluating the test data.

3.1.1 Furnace Characteristics

During the entire testing program, the furnace was loaded with "low loss" cartridges similar to the "Standard Cartridge" (Part No. 800C878G01A) used in the M518 program. In order to reduce thermal coupling, the present low loss cartridge was shorter than the "Standard Cartridge" so that it extended up to but not into the heat leveler. Also, it was open at the hot end so that it was evacuated to improve the efficiency of the axial thermal insulation. The power/temperature characteristics of such a configuration were well-known from previous work in the M518 studies so that the net furnace power (net heat loss) could be calculated by subtracting the cartridge losses from the total power input.

3.1.1.1 Furnace Power/Temperature Characteristics

The intrinsic heat loss of the furnace as a function of temperature was one of the most important characteristics measured for the system. All measurements were made with the system in steady state as determined by the absence of temperature drift on a control thermocouple, usually CTC-1. The actual calibration data, however, was expressed in terms of the HOT-1 thermocouple since only the measurement thermocouples are accessible during normal system operation.

The usual technique of measurement was to heat the furnace with a larger power input than required for the desired equilibrium temperature and then reduce the power when the appropriate temperature was reached. As a matter of convenience, it was frequently useful to use the relation

$$\Delta P = C_1 \frac{dT}{dt} \tag{3.1}$$

ΔP = difference between input power and equilibrium power

C_1 = heat capacity of heat leveler (about 980 J/°C)

$\frac{dT}{dt}$ = Drift of CTC-1 in °C/sec

to calculate the power changes needed to bring the furnace into steady state. This technique considerably reduced the time necessary to obtain a given data point and increased the accuracy of the information.

The furnace power/temperature characteristics are shown in Fig. 3-2 which also shows the M518 characteristics for comparison. For quantitative use, the net furnace power losses can best be obtained from the empirical equation

$$P = (a + bT)^4 \tag{3.2}$$

where the least squares fit for a and b (including data for T > 1100°C) gives

$$\begin{aligned} a &= 1.0830 \pm 0.0239 \\ b &= 1.7403 \times 10^{-3} \pm 2.75 \times 10^{-5} \ . \end{aligned} \tag{3.3a}$$

The same power equation fits the total power/temperature curve with the coefficients changed to

$$\begin{aligned} a &= 1.1372 \pm 0.019 \\ b &= 1.7816 \times 10^{-3} \pm 2.05 \times 10^{-5} \ . \end{aligned} \tag{3.3b}$$

If only the data for temperatures less than 1100°C is used, then the equation changes slightly and the power measured for temperatures in the vicinity of 1150°C is found to be one or two watts greater than anticipated from the balance of the data. This excess power is probably due to gaseous conduction in the furnace.

Curve 656443-A

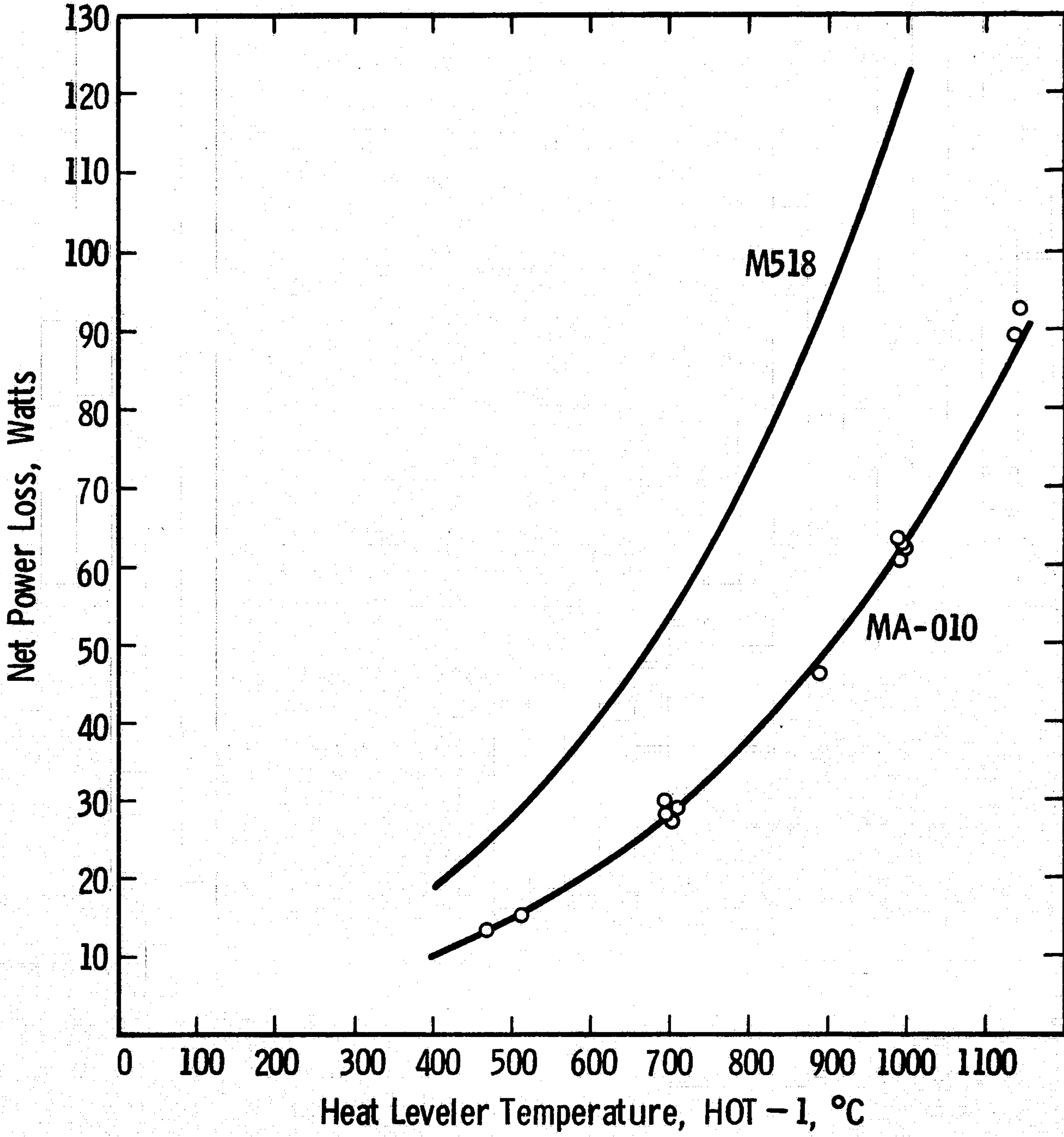

Fig.3-2—Net power loss

For most of the measurements, the pressure measured in the furnace during the measurements was of the order of 1 to 3×10^{-4} torr, however, for measurements near 1150°C, the pressure ranged from 7×10^{-4} to 1.5×10^{-3} torr. Simple calculations of the heat transfer by the residual gas at low pressures (see e.g. Dushman, "Vacuum Technique") indicates that at about 1100°C, the gaseous heat loss as a function of pressure are of the order of

$$P_g = 2 \times 10^3 \text{ p watts (p in torr)} \qquad (3.4)$$

Thus, the excess power loss observed is in excellent agreement with that expected from kinetic theory considerations. It also follows that an operational pressure limit for furnace pressure lies about 2×10^{-3} torr; otherwise, the gaseous heat losses become excessive.

3.1.1.2 Stability of Furnace Characteristics

The precision with which the power/temperature characteristics of the MEF can be measured allows the stability of these characteristics to be measured. The effect of continued operation can best be seen from the Table 3-1 which shows the total furnace power losses and heater resistances for temperatures near 1000°C at various times during the course of the testing program. The furnace operating history corresponding to the various dates can be deduced from Fig. 3-3.

TABLE 3-1

Date	T_{HOT-1} °C	P_{in} watts	P_{1000} watts	R ohms
12-21-73	992.2	68.87	72.0	3.609
1-11-74	1000.2	70.96	70.9	3.611
1-14-74	998.5	71.12	71.4	3.608
2-12-74	992.6	71.5	72.8	3.611
5-03-74	996.9	71.4	72.0	3.616
5-20-74*	992.3	73.02	74.4	3.615

*After furnace flange drilled at WANL.

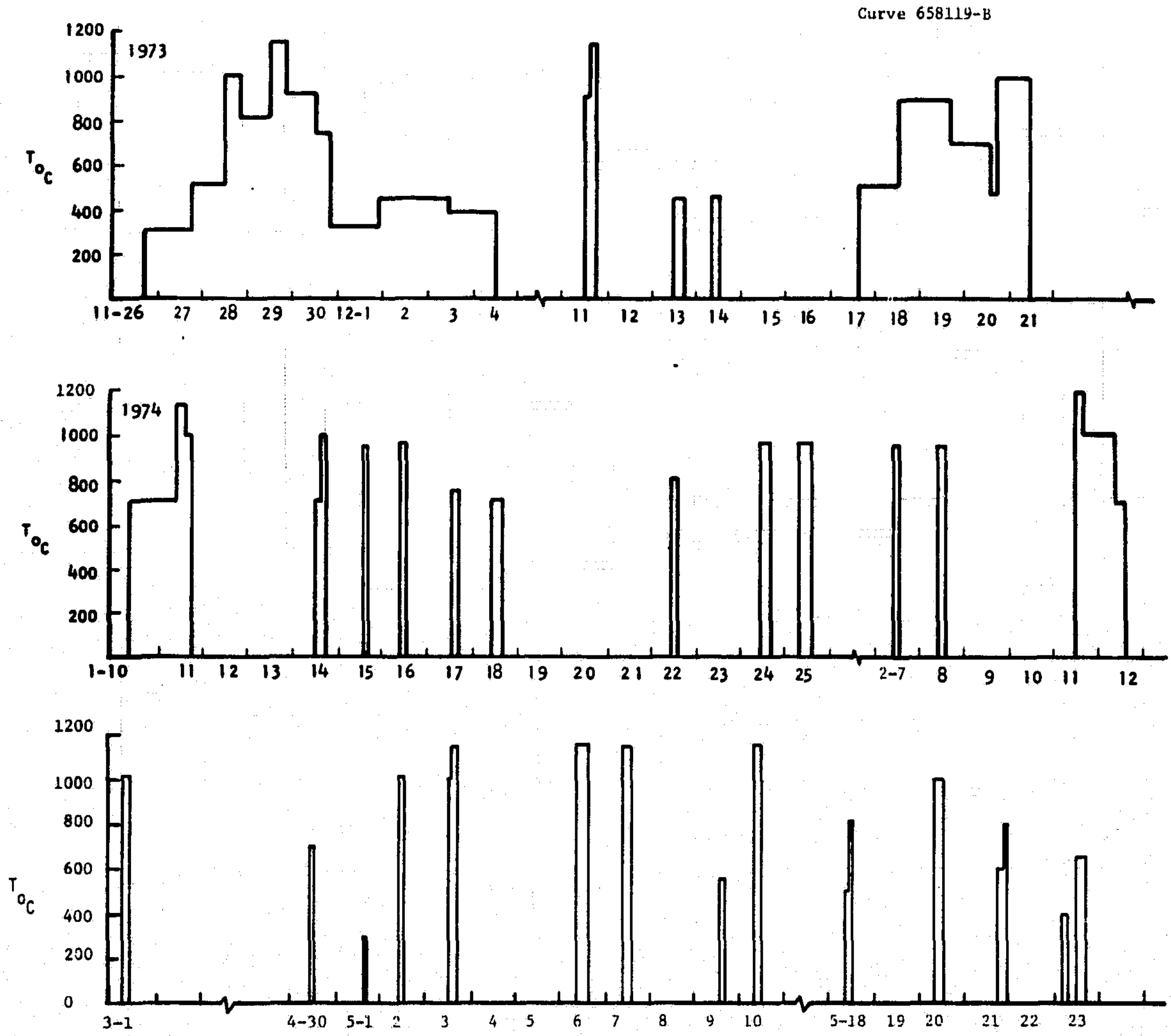

Fig. 3-3—Operating history of MEF

The values for the power at 1000°C were extrapolated from the measured input power using the derivative of Eq. (3.2) and the parameters (3.3b). The heater resistances were determined from the individual heater voltages and currents of the two heater sections.

The data in Table 3-1 would indicate that there has been a gradual increase in the power required to maintain a given temperature. Such an increase could result from a slight loss in efficiency of the heat shields due to oxidation of unplated molybdenum components. The severity of this oxidation is a function of both the gas pressure and composition, the temperature of operation and the time at temperature. This effect illustrates the second way in which poor furnace vacuum leads to degraded performance. The first way is gaseous heat conduction discussed in section 3.1.1.1 which is, of course, reversible. The degradation of the radiation shields by oxidation, however, is a permanent change.

It should be pointed out that while there is a measurable deterioration of the furnace power/temperature characteristic, the actual amount of the change is only about 2 watts at 1000°C, and then only after operation for times much longer than expected during the actual mission.

Of equal importance with the power/temperature characteristic is the stability of the heater resistance. Preliminary experiments showed that Kanthal A-1 ablated severely in vacuum without protection. Even when incased in the alumina heater form, the heater resistance changed drastically in five or ten hours of operation. In the present design, the heater wire is additionally incased in high purity alumina cement. The efficacy of this technique is well demonstrated by the data which indicates a negligible increase in heater resistance over the testing period.

Figure 3-3 is a schematic representation of the MA-010 prototype furnace thermal history, and illustrates the number and

frequency of furnace test runs. More quantitatively, the total operating time (furnace power on) was 459.5 hours. Of this total, 133 hours were spent at temperatures exceeding 900°C. This total includes 72 hours above 1000°C, of which the furnace spent 22 hours at 1150°C, with about 3 hours at 1190°C. These totals do not include time spent at elevated temperatures during cooldown when the furnace input power was turned off.

3.1.1.3 Heat Leveler Temperature Distribution

The temperature measured by the control thermocouples (CTC's) and the measurement thermocouples (HOT-1, 2) give an indication of the radial temperature drop which occurs in the heat leveler. This drop is of the order of 5°C at a heat leveler temperature of 550°C and 12°C at 1150°C with low loss cartridges and would be greater with experiment cartridges drawing greater power.

The axial temperature distribution in the heat leveler cannot be determined by the furnace thermocouples so that a special temperature probe was constructed to measure it. This probe consisted of a cartridge similar to the low loss cartridge but have a stack of circular radiation shields extending into the heat leveler cavity. Five thermocouples were spaced along this section; the radiation shields prevented interaction between the thermocouples and also insured that the thermocouples "saw" only a small section of the heat leveler cavity. The results of the measurements are shown in Fig. 3-4. The heat leveler indeed has an extremely constant temperature over about half of its length and the temperature then begins to drop off. The last thermocouple unfortunately was not in the actual cavity but rather in the gradient tube region and as a result measured a much lower temperature than the other four. This data is of importance in calculating the performance of experiment cartridges in that it indicates that the "effective heat leveler temperature" for cartridge design calculations may be five to ten degrees cooler than the measured temperature.

Curve 658196-A

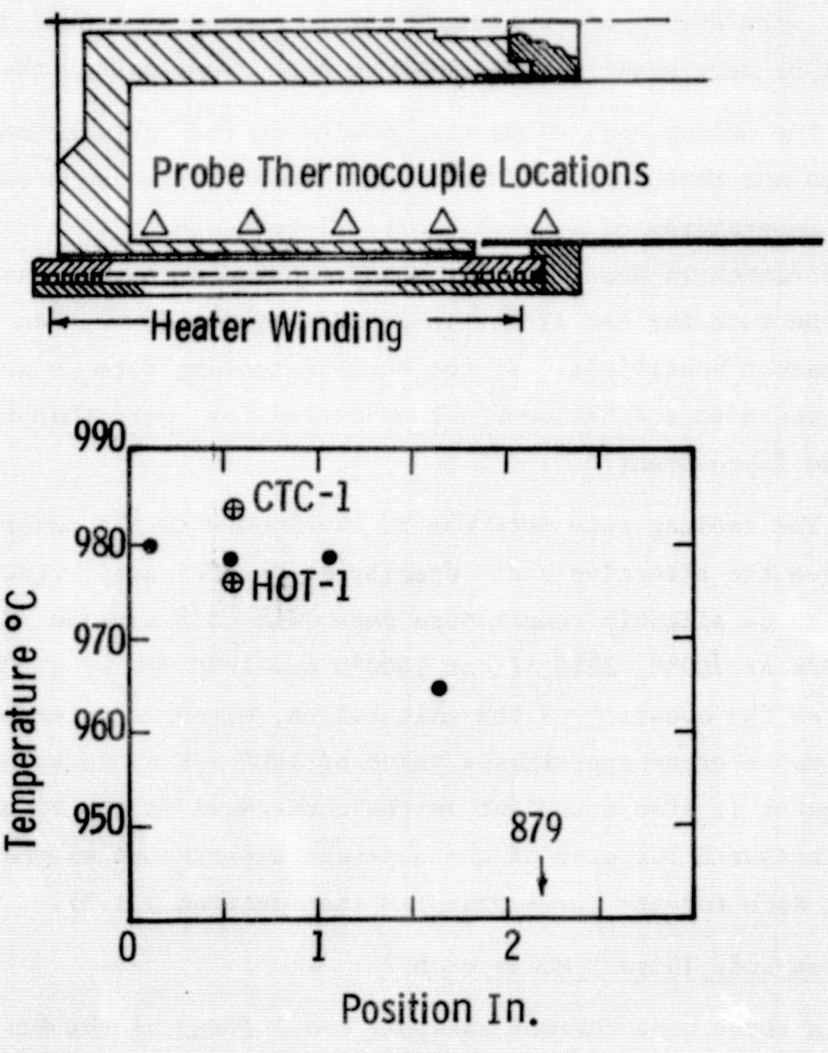

Fig. 3-4—Heat leveler temperature profile

3.1.2 Furnace Cooling Rate

The passive furnace cooling rate was measured with low loss cartridges both under vacuum conditions and with helium added to increase the heat losses. The observed rates as a function of temperature are shown in Fig. 3-5. It should be emphasized that the normal cool rate is valid only for the low loss cartridges; with regular experiment cartridges which conduct appreciable power, the rate will be faster. The effect of cartridges for the helium quenched cooling rates will be very small due to the high heat flux through the gas.

The helium cool rates are labeled on the curve as one dosage, two dosages, and three dosages. These correspond to helium pressures (at room temperature) of about 11 torr, 22 torr and 33 torr respectively. Little difference is found between the 22 torr and 33 torr cases; however, the rate for the 11 torr case is slightly lower than for the higher pressure conditions. If the maximum cooling rate is required, then a second dosage of helium might be called for; more than two dosages produce no improvement.

The cooling rate data can be combined with the power loss data to give the effective heat capacity of the furnace. This parameter turns out to be slightly temperature dependent with a value of C_p = 960 J/K at 700°C, 1040 J/K at 1000°C and 1080 J/K at 1100°C. Depending on the accuracy of the calculation, either the temperature dependent value or an approximate value of 1000 J/K could be used. This parameter is also dependent on the cartridges in the furnace and should be measured for each of the separate experiments to provide the best input data for the Three Node TAM (see section 3.1.3).

3.1.3 Three Node Thermal Model of MEF

A three node thermal analysis model (TAM) of the Multipurpose Furnace was developed to predict gross furnace performance both for experiment cartridge development and for use by Rockwell International Space Division in their integrated TAM of the entire Docking Module.

Curve 656444-A

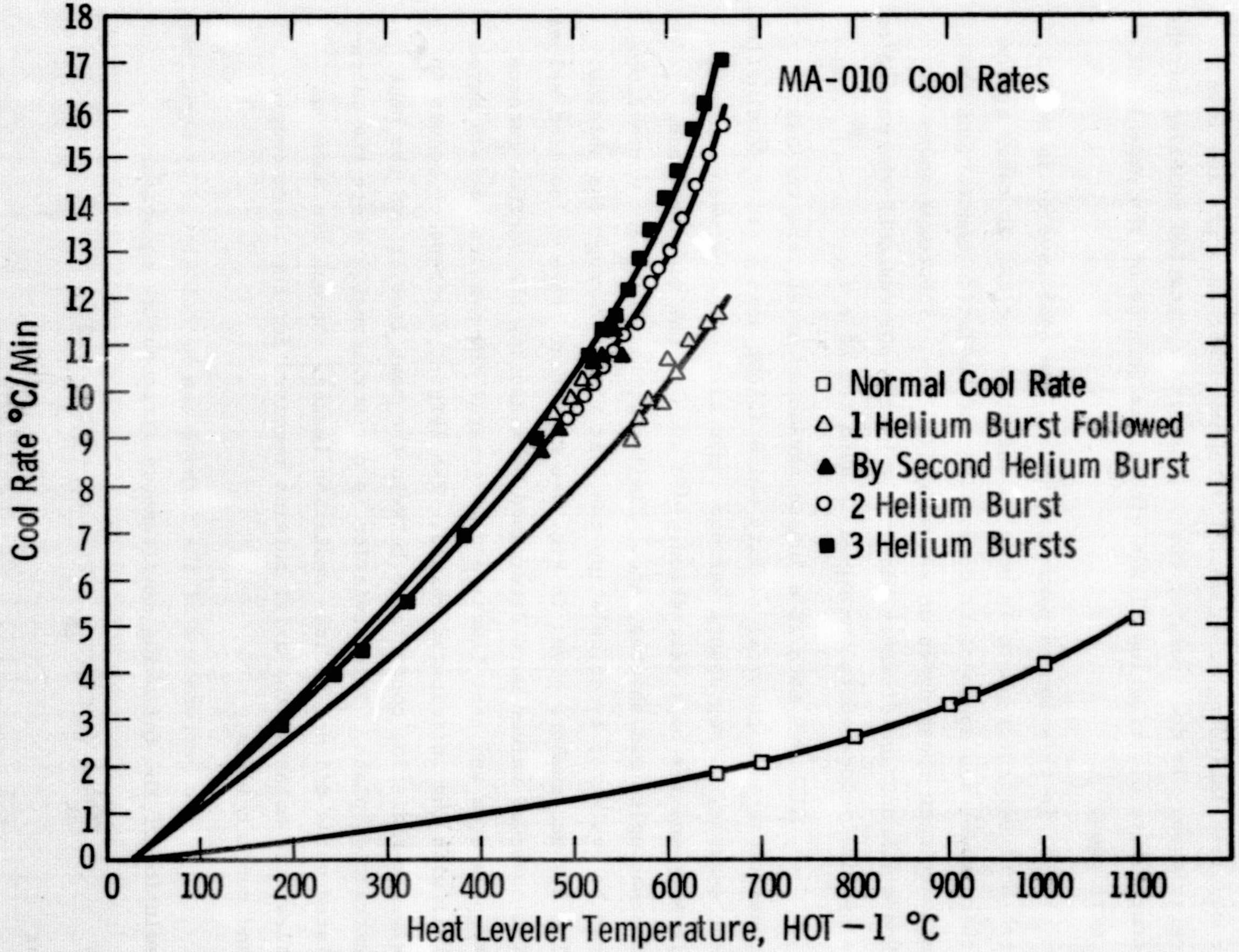

Fig. 3-5—MEF cooling rates

The three node TAM provides a simple and quite accurate means for predicting furnace temperatures and powers for different operating conditions including experiment cartridges other than the low loss cartridges. It does not, of course, provide a detailed modeling of the temperature distribution within either the furnace or the experiment cartridges.

In this lumped parameter model, the heat leveler is Node 1, the heat extractor plate is Node 2, and the outer can is taken as the third node; and appropriate conduction and radiation connections are made between these nodes as shown in Fig. 3-6. The temperature of Nodes 1 and 2 are directly measurable by the HOT and COLD thermocouples; a specially-located thermocouple is used for Node 3.

Although this is a lumped parameter model, the various connections have physical reality which allows some a priori evaluation. For example, K1 represents various conduction paths between the heat leveler and the heat extraction plate such as the support tubes, thermocouples and sheaths, etc. Similarly, the radiation connections can be evaluated by calculating the heat fluxes through the shields. The assumed numbers given in Fig. 3-6 represent these calculated values. The observed values were determined by measuring the various furnace temperatures and heat fluxes and in general the measured values agree well with the anticipated values. The largest discrepancy occurs in $\kappa 1$, the radiation conductance between the heat leveler and the heat extraction plate. This deviation is not unreasonable since the calculated value did not include radiation leakage through the numerous clearance holes in the axial shields required for the thermocouples and current loads.

The performance of the furnace can be calculated by numerical solution of the following simultaneous differential equations.

$$\frac{dT1}{dt} = (1/C1)(P_{IN} - P1 - P2 - PK1 - PK2) \qquad (3.5a)$$

or

$$\frac{dT1}{dt} = (1/C1)(-P1 - P2 - P3 - PK1 - PK2) \qquad (3.5b)$$

Fig. 3-6
THREE NODE THERMAL MODEL

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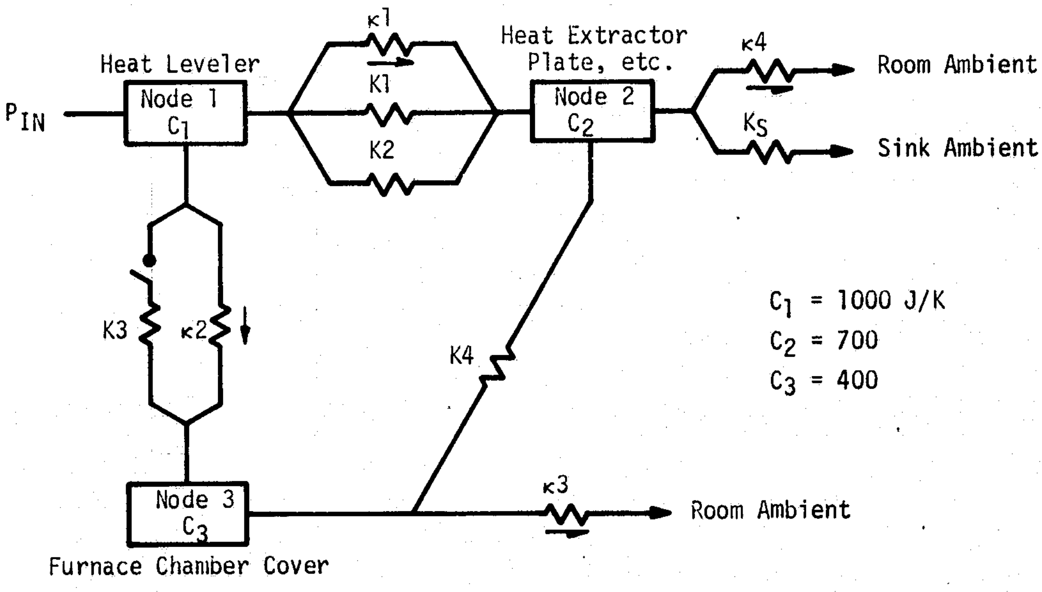


	$P = K(T_i - T_j)$	Assumed WK^{-1}	Observed WK^{-1}	Notes
K1	Conductive Paths	0.025	0.018	
K2	Experiment Cartridge		8.0(-3)	(1)
K3	Gas Conduction in Helium Quench	.50	0.36/0.49	(2)
K4	Conductance through Furnace Chamber Cover	.181	.100	(3)
K_S	Heat Sink Conductance	1.54	1.13	
	$P = \kappa(T_i^4 - T_j^4)$	WK^{-4}	WK^{-4}	
κ1	Radiation Conductance from Heat Leveler to Heat Extractor Plate	1.31(-12)	9.7 (-12)	
κ2	Radiation Conductance from Heat Leveler to Furnace Chamber Cover	1.14(-11)	7.95(-12)	
κ3	Radiation Conductance from Furnace Chamber Cover to Ambient	3.36(-9)	2.16(-9)	
κ4	Radiation Conductance from Instrumentation Compartment Cover to Ambient	5.15(-10)	5.15(-10)	

Notes: (1) Observed value for low loss cartridge.
(2) Values for one or two dosages respectively.
(3) Change in value due to geometrical factor.

$$\frac{dT2}{dt} = (1/C2)(P1 + P2 + P4 + PK1 - PS - PK4) \tag{3.6}$$

$$\frac{dT3}{dt} = (1/C3)(PK2 - P4 - PK3) \tag{3.7a}$$

$$\frac{dT3}{dt} = (1/C3)(PK2 + P3 - P4 - PK3) \tag{3.7b}$$

where the P's refer to heat fluxes through the conductance connections and the PK's to the heat fluxes via the radiation connections. Equations 3.5a and 3.7a apply during the heat up and soak times whereas 3.5b and 3.7b are valid during the helium quench. During the heat up, the input power is constant, while in the soak period, $\frac{dT1}{dt}$ is set at zero and the input power is calculated as a variable. The model as illustrated is applicable to the test configuration, Fig. 3-1, used to measure furnace performance in the laboratory. In order to calculate the performance of the system in the docking module, the model must be changed very slightly by connecting the radiative conductance $\kappa 1$ to Node 2 rather than to ambient. Although this changes Eq. 3.6 slightly, the values of the individual connection elements are not affected.

The model was tested by performing a furnace run with known input powers during the heat-up and soak phases. Following the soak phase, the furnace was cooled passively to 700°C when helium was admitted to accelerate the cooldown. Figure 3.7 shows the calculated temperatures as solid lines with the observed values as data points. Generally, the agreement is excellent; however, a deviation in the transient response of T3 indicates a slightly larger heat capacity is required for Node 3 if greater accuracy is necessary. Under steady state conditions, the predicted furnace losses agree within 0.5 watt with the values calculated from Eq. 3.2. This agreement, of course, depends on having a good representation of the cartridge conductance K2 which must be evaluated for every experiment.

Curve 658195-A

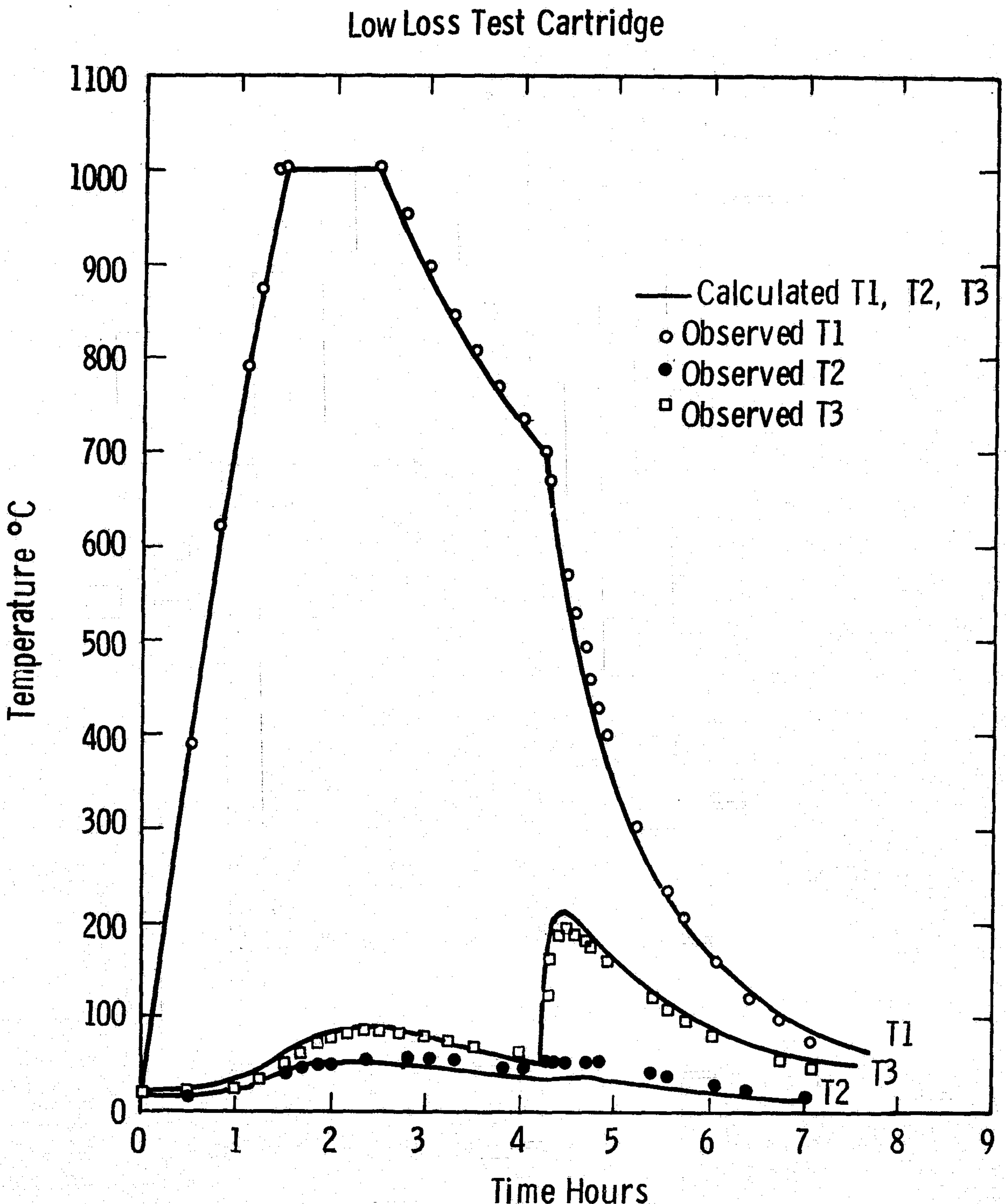


Fig. 3-7—Observed vs predicted furnace temperatures

3.1.4 Furnace Pump-Down Requirements

An adequate vacuum must be maintained in the furnace during operation for the reasons discussed in section 3.1.1.2. Because of the structure of the furnace, coupled with the experimental procedural and time line requirements, the demands on the pumping line are more severe than would be the case with a simple laboratory vacuum system.

The internal structure of the furnace contains a very large surface area. For example, the fired graphite heat leveler will readily absorb large quantities of gas, including water vapor, when the furnace is opened to the atmosphere, as is required for cartridge loading. When the furnace is subsequently heated, outgassing occurs in several bursts as different species with different energies of binding are desorbed. This behavior is clearly illustrated by the pressure vs temperature curves in Appendix B. The pumping line must have sufficient capacity to handle these bursts of outgassing in order to prevent the pressure in the furnace from becoming excessive during heat up.

Early in the program, Rockwell contemplated the use of a section of 3/8" O.D. pump line in the DM. Our early tests, with a 28" section of 3/8" line in the system, showed this configuration to be inadequate, as shown in Appendix B. We replaced the 3/8" line with 26" of 3/4" O.D. line which was satisfactory. Later, a one-inch pump line was designed by Rockwell. As an addendum to this contract, a detailed mock-up of the Rockwell design was constructed and tested. Our test results are shown in Appendix B and prove the one-inch line to be entirely adequate to meet the furnace vacuum requirements, although the margin of safety was quite small.

3.2 Helium Package

The detailed design drawings for the helium package (HP) are contained in Appendix A. The prototype HP, including the associated lines, was leak checked while evacuated. Both the storage and dosage cavity were also leak checked while pressurized to 300 psi.

Functional testing of the HP requires its use in conjunction with the furnace. These test results are included with the furnace tests in section 3.1.2.

3.3 Control Package Performance

A number of tests were performed on the modified control package to verify and characterize the operation of the new control functions. These tests were made on the control package itself with the use of simulated thermocouple signals, a dummy heater load, an oscilloscope, a dc power supply, a precision 5-digit digital voltmeter, and a counter.

The first test performed was to obtain a calibration curve of true control temperature on control thermocouple CTC-1 (or CTC-2) vs soak setting. This curve was obtained by setting the control potentiometer at specific points and then adjusting the simulated CTC-1 signal to obtain a 50-50 heater waveform (i.e., 50% output power). The simulated TC signal was then measured and the corresponding TC temperature was recorded from the new reference tables for Chromel-Alumel thermocouples. The resulting temperature calibration curves are shown in detail in Figs. 3-8, 3-9, 3-10, and 3-11.

The calibration of the "shorted control TC protection" circuit was checked by simulating HOT-1 and HOT-2 thermocouple signals and measuring the input voltages at which each caused K2 to be energized. These trip levels occurred at 48.48 mV and 48.45 mV corresponding to HOT-1 and HOT-2 temperatures of 1190°C and 1189°C respectively. For each case it was verified that K1 and heater power was shut off and that the overtemperature light was energized.

A series of tests were then performed to determine the performance of the variable rate controlled cooldown function. For all of these tests, the CTC-1 thermocouple signal was continuously adjusted to maintain a 50-50 output heater waveform throughout the controlled cooldown period. Measurements were made of the change in millivolts of the CTC-1 signal and the period of the clock oscillator every five minutes during each cooldown test. The millivolts change

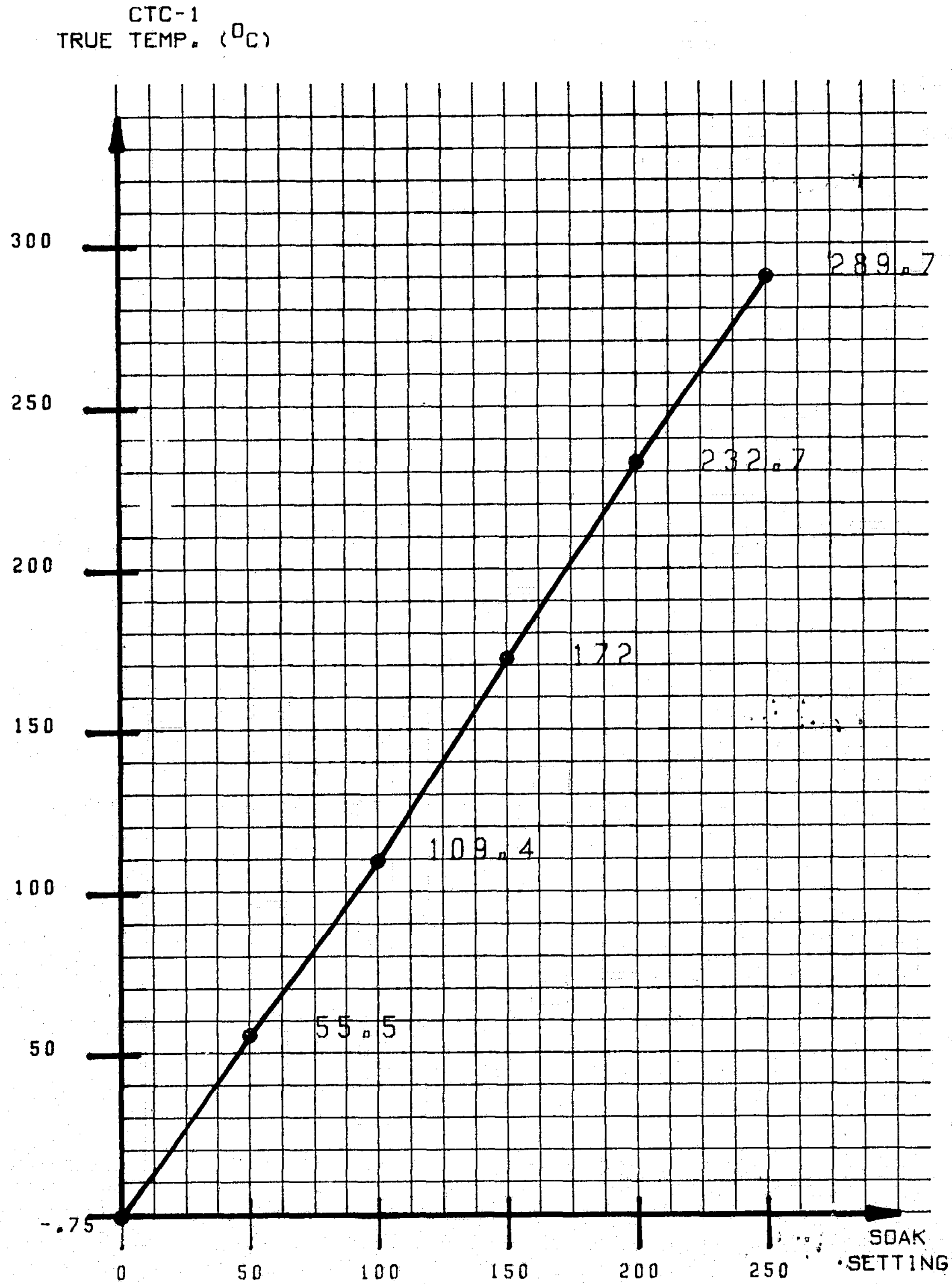


Fig. 3-8. TRUE CONTROL TEMPERATURE VS. SOAK SETTING (0-250)

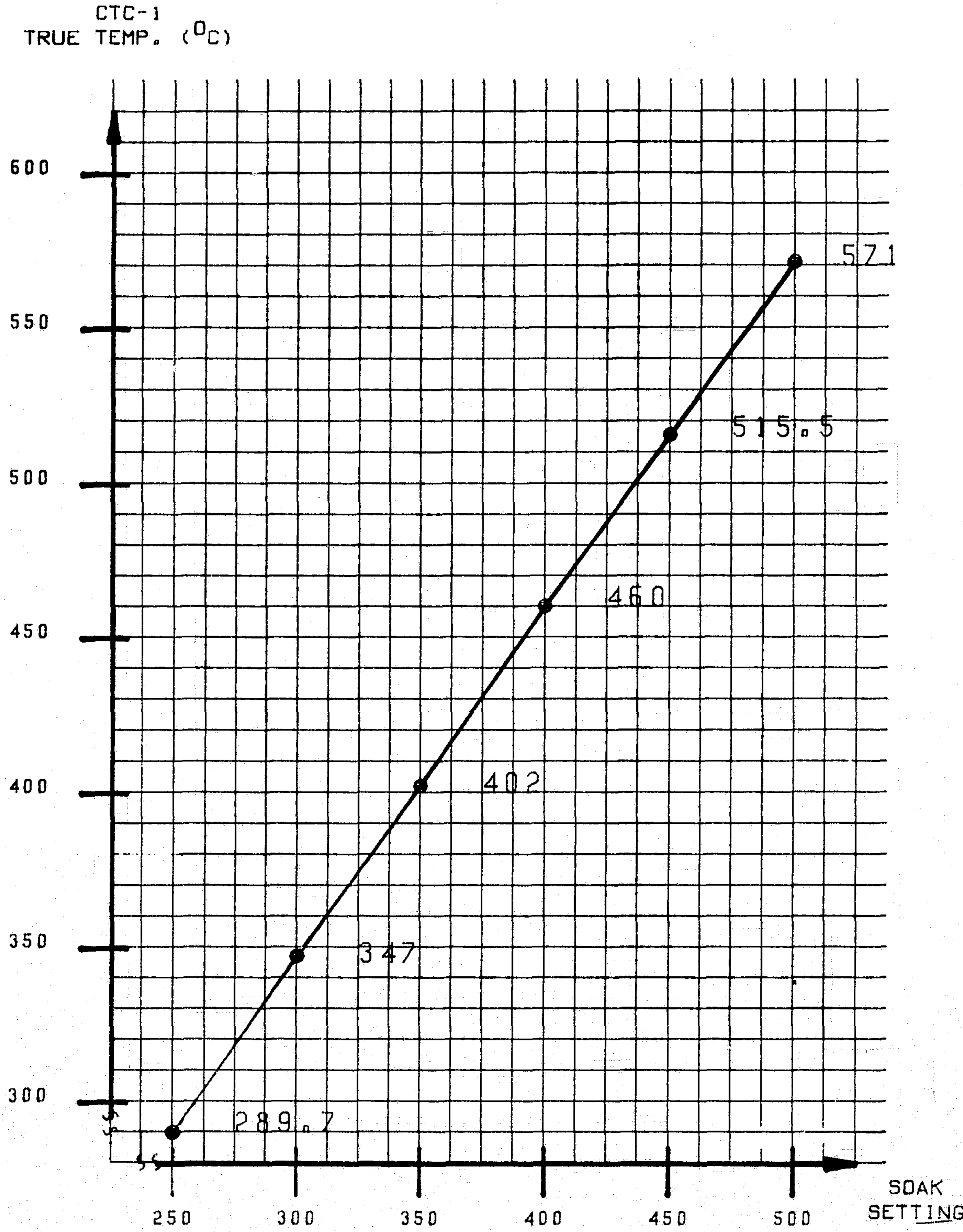


Fig. 3-9. TRUE CONTROL TEMPERATURE VS. SOAK SETTING (250-500)

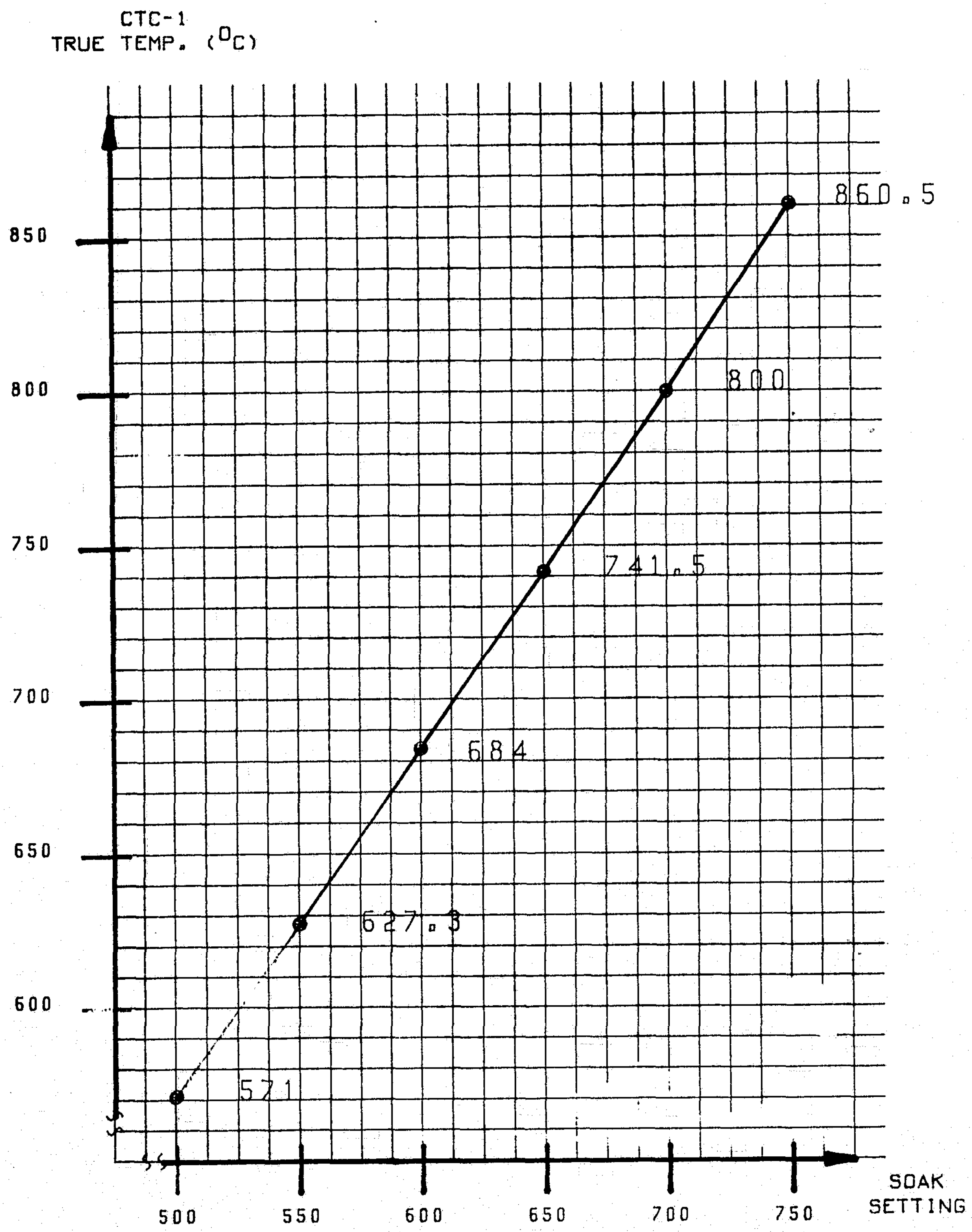


Fig. 3-10. TRUE CONTROL TEMPERATURE
VS. SOAK SETTING (500-750)

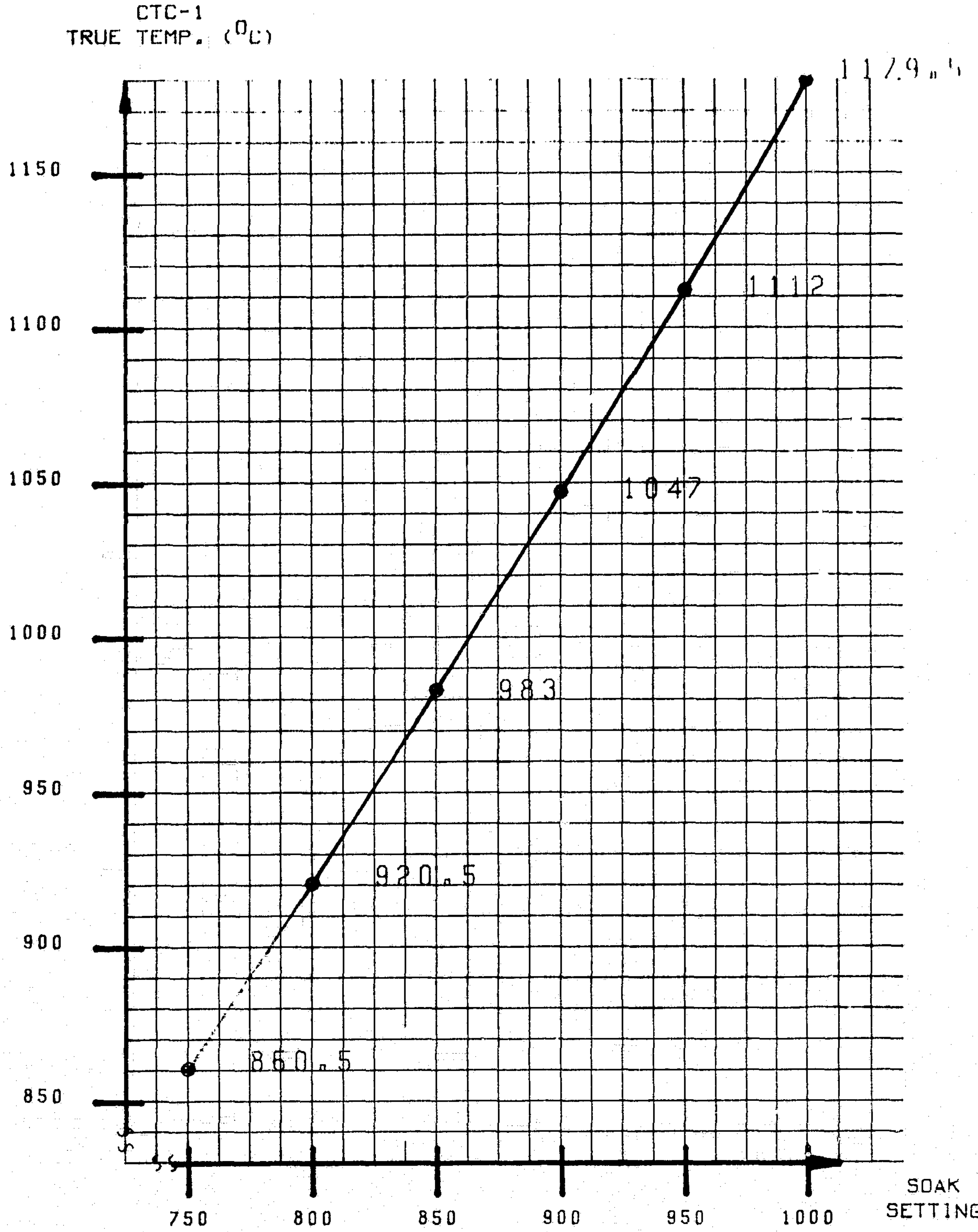
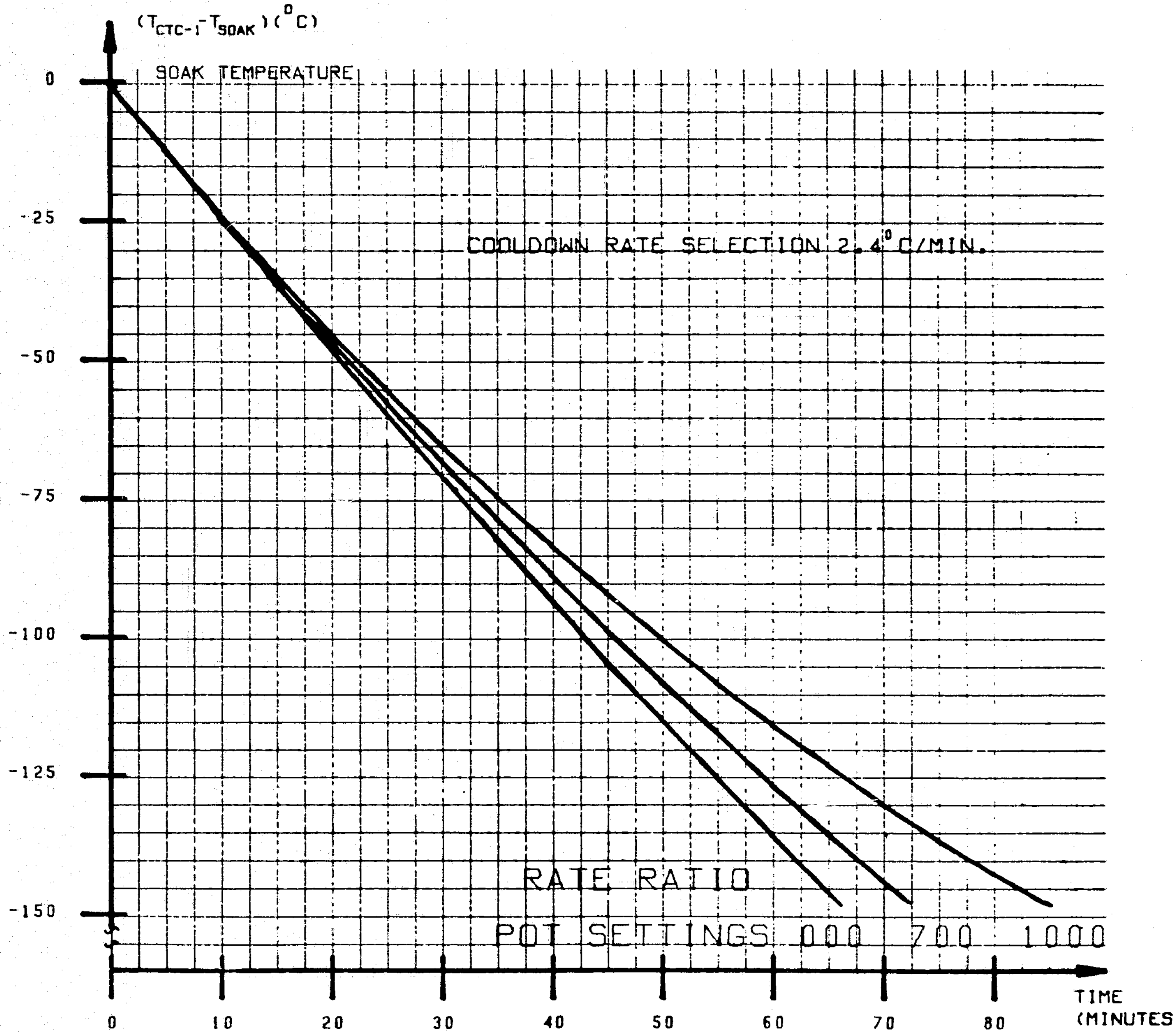


Fig. 3-11. TRUE CONTROL TEMPERATURE
VS. SOAK SETTING (750-1000)

was transferred into a corresponding linearized CTC-1 temperature change to obtain the set of curves shown in Fig. 3-12. This shows the controlled temperature variation from soak temperature ($T_{CTC-1} - T_{soak}$) as a function of time and "rate ratio" potentiometer settings. One might note that the initial cooldown rate setting for all these tests was 2.4°C/min. If initial cooldown rates of 1.2 or 0.6°C/min are selected, the curves would be identical except that the time scales would be increased by factors of 2 and 4, respectively. It should also be noted that the visible irregularities (particularly for the 000 pot setting curve) do not really exist but are a result of drafting errors used to obtain the curves.

Another useful set of curves is shown in Fig. 3-13. This figure shows the normalized cooldown rate vs cooldown temperature as a function of rate ratio potentiometer settings. Definitions of normalized cooldown rate and cooldown temperature are given on the curve.



CONTROLLED COOLDOWN TEMPERATURE (LINEAR) VS. TIME

Fig. 3-12

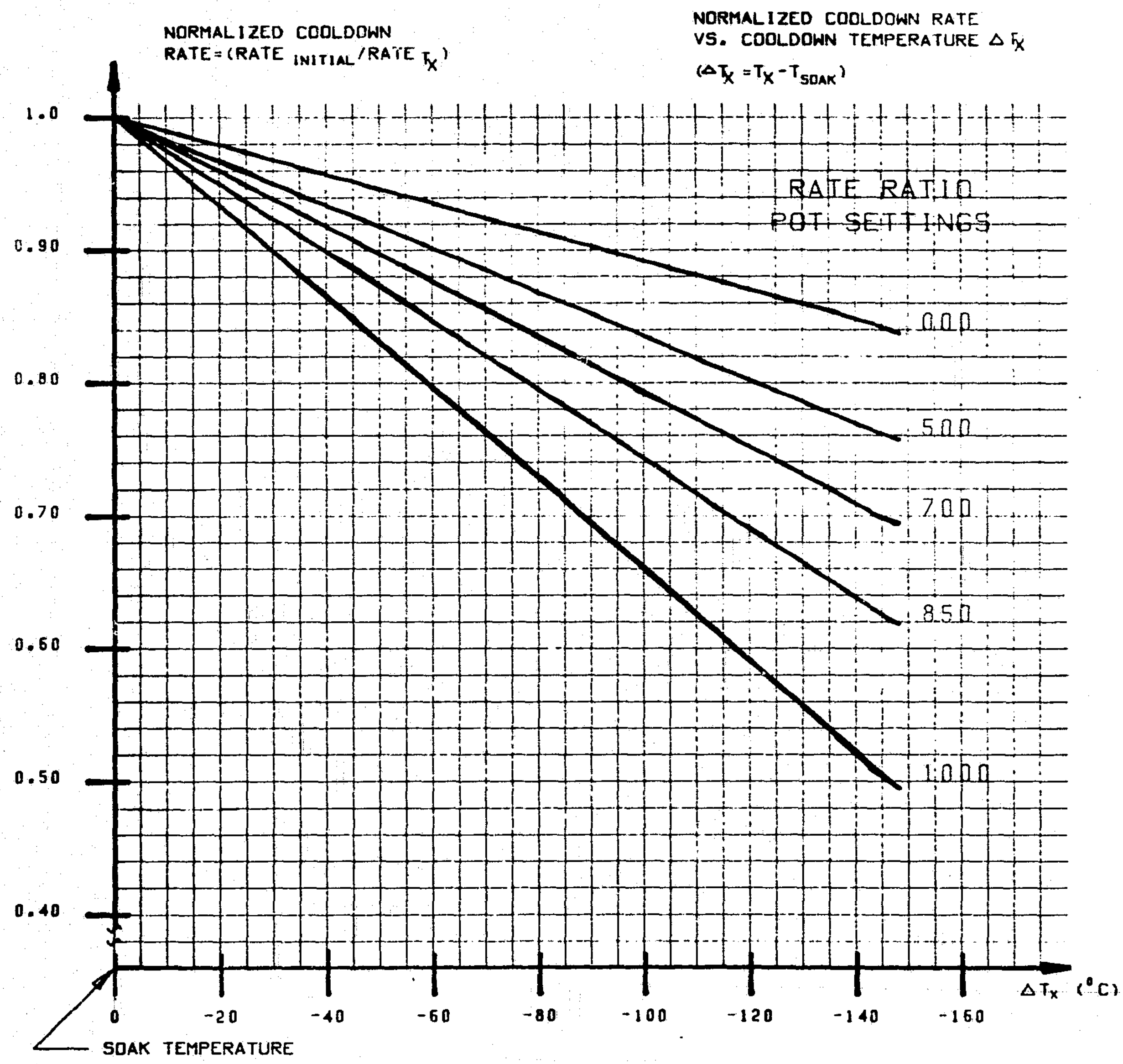

NORMALIZED COOLDOWN RATE VS. COOLDOWN TEMPERATURE ΔTX
(ΔTX = TX - TSOAK)
NORMALIZED COOLDOWN RATE = (RATE INITIAL / RATE TX)
RATE RATIO POT SETTINGS
0.00
5.00
7.00
8.50
10.00
1.0
0.90
0.80
0.70
0.60
0.50
0.40
0
-20
-40
-60
-80
-100
-120
-140
-160
ΔTX (°C)
SOAK TEMPERATURE

Fig. 3-13

4. SYSTEM TESTS

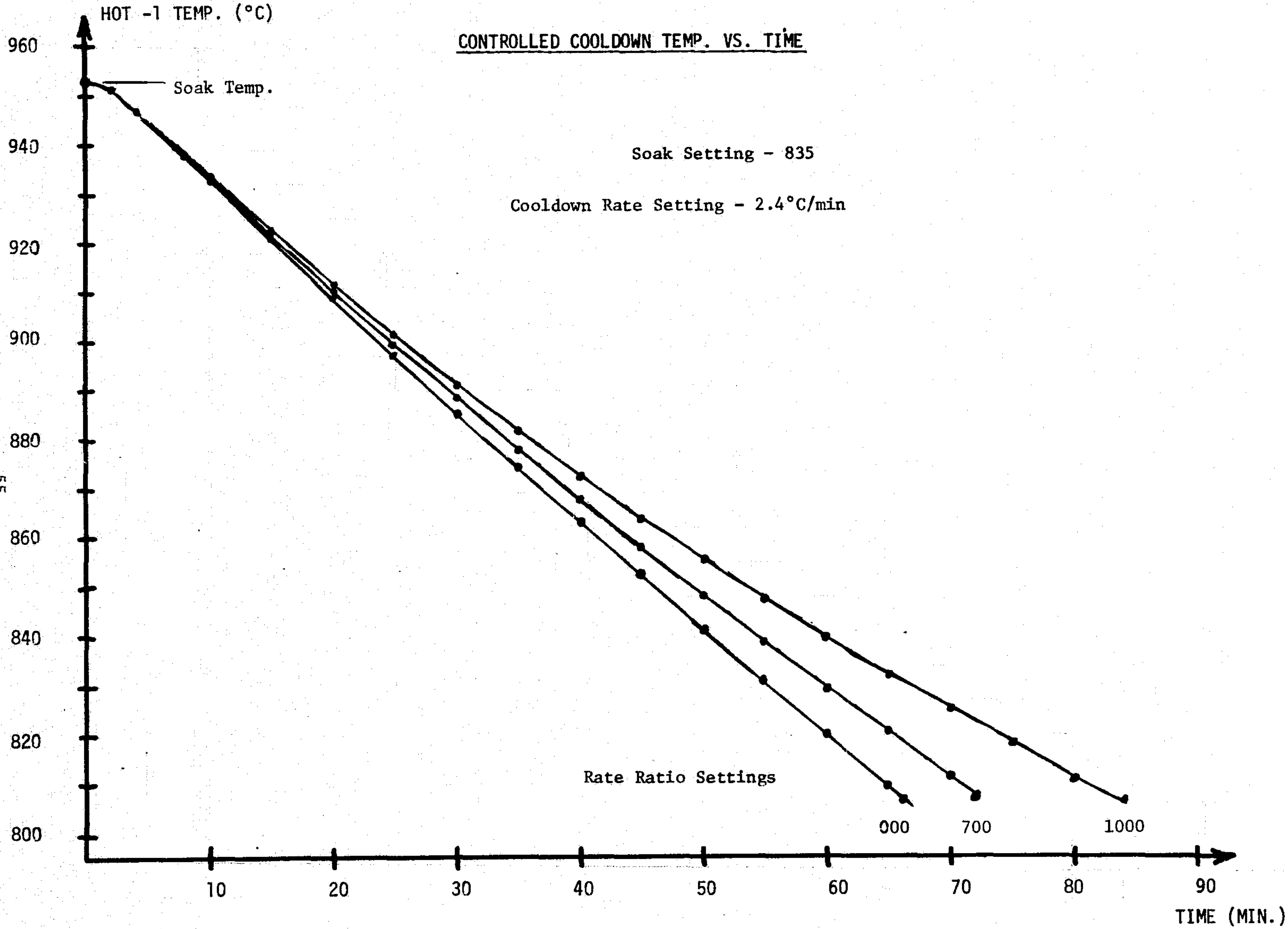
4.1 Introduction

The control package and the helium package both interact with the furnace independently. That is, the control functions are in an "off" mode whenever the helium package function is utilized. Therefore, the system tests of significance are furnace-helium package and furnace-control package. The furnace-helium package system is discussed in section 3.1.2. The furnace-control package system is discussed below in terms of a system test of the controlled cooldown function.

4.2 Furnace-Control Package System -- Controlled Cooldown Function

A number of tests were performed to verify the operation of the variable rate cooldown function in a complete system configuration. These tests were all run with "low loss" cartridges in the furnace. For each test run, a "soak setting" of 835 was used which yielded a control thermocouple CTC-1 "soak" temperature of 960°C. The corresponding heat leveler HOT-1 thermocouple temperature during soak was measured at 952.5°C. The first set of tests were run with a "cooldown rate" selection of 2.4°C/min and the "rate ratio" setting was used as a variable. Measurements of CTC-1 and HOT-1 thermocouple signals were made at specific time intervals from the beginning to the end of each controlled cooldown period.

The results of the first set of tests are shown in Fig. 4-1 with HOT-1 temperature plotted as a function of time and "rate ratio" setting. The plot of HOT-1 vs time is of particular interest since this is more representative of the temperature-time profile seen at the hot end of the experiment cartridges than that obtained by plotting

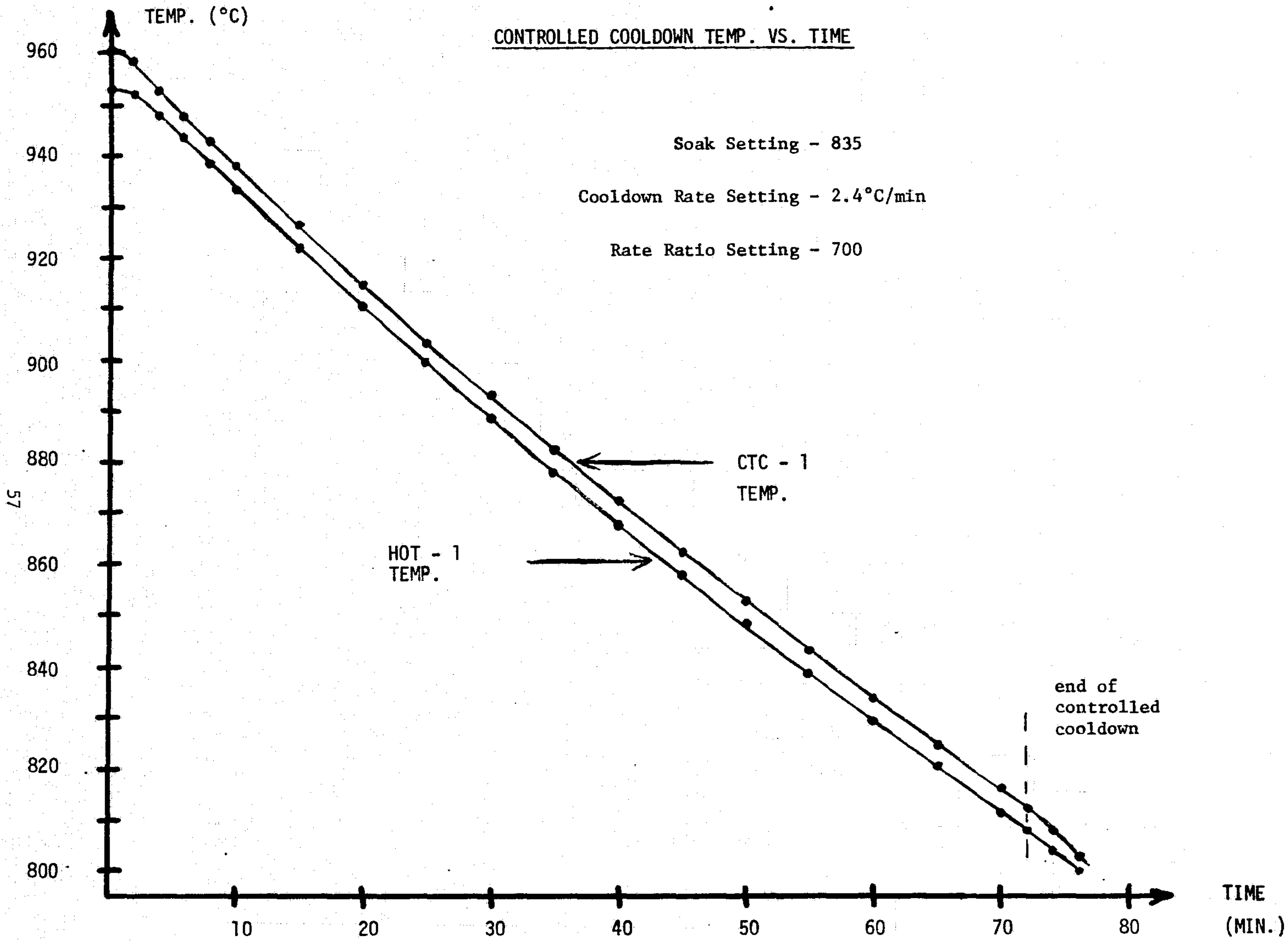


HOT -1 TEMP. (°C)
CONTROLLED COOLDOWN TEMP. VS. TIME
Soak Temp.
Soak Setting - 835
Cooldown Rate Setting - 2.4°C/min
960
940
920
900
880
860
840
820
800
Rate Ratio Settings
000
700
1000
10
20
30
40
50
60
70
80
90
TIME (MIN.)

Fig. 4-1

control thermocouple CTC-1 vs time. One might note that there is a delay of several minutes between the start of controlled cooldown and when HOT-1 temperature starts to decrease at the desired rate. This delay is caused mainly by the thermal mass of the heat leveler and the resulting thermal time delay between CTC-1 and HOT-1 thermocouples. After this delay, however, the variable rate cooldown function performed very well as one can see by comparing this set of curves (Fig. 4-1) to those generated when testing the control package by itself (see Fig. 3-12).

Two other figures are presented to demonstrate operating characteristics of the combined system. The first of these (Fig. 4-2) compares CTC-1 temperature and HOT-1 temperature for one of the test runs. This plot clearly shows the temperature differential between HOT-1 and CTC-1, the thermal lag between HOT-1 and CTC-1, but most importantly the good tracking between these two temperatures. Therefore, since we know that the control package provides very smooth programmed temperature control of CTC-1, then HOT-1 temperature will be controlled similarly. The second figure (Fig. 4-3) shows the results of two controlled cooldown test runs with a cooldown rate setting of 1.2°C/min instead of 2.4°C/min. The results of these tests are virtually identical to those shown in Fig. 4-1 except that the time scale is increased by a factor of two (2), as it should be.



TEMP. (°C)
CONTROLLED COOLDOWN TEMP. VS. TIME
Soak Setting - 835
Cooldown Rate Setting - 2.4°C/min
Rate Ratio Setting - 700
960
940
920
900
880
860
840
820
800
CTC - 1
TEMP.
HOT - 1
TEMP.
end of
controlled
cooldown
10
20
30
40
50
60
70
80
TIME
(MIN.)

Fig. 4-2

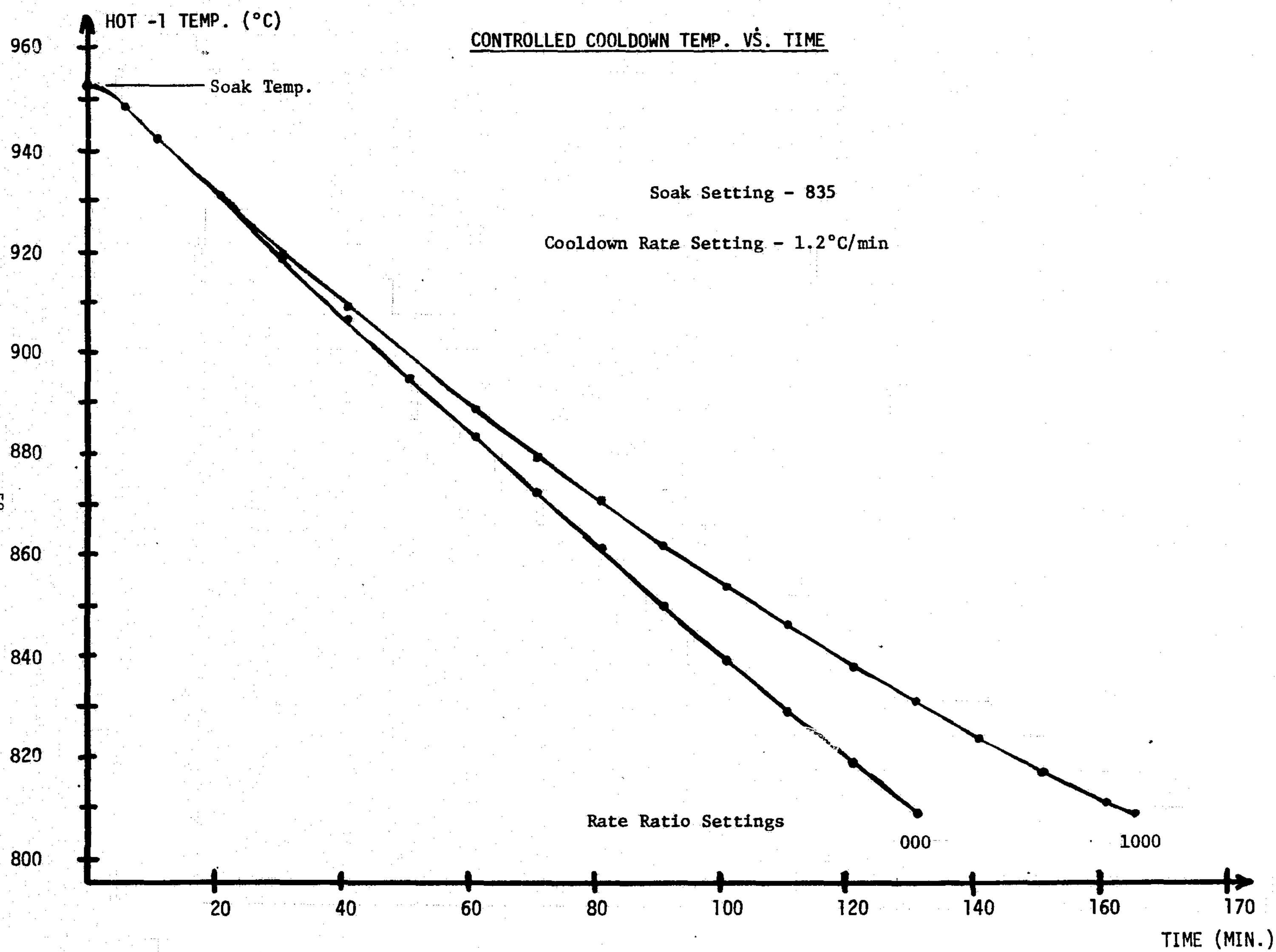

HOT -1 TEMP. (°C)
CONTROLLED COOLDOWN TEMP. VS. TIME
960
Soak Temp.
940
Soak Setting - 835
920
Cooldown Rate Setting - 1.2°C/min
900
880
860
840
820
800
Rate Ratio Settings
000
1000
20
40
60
80
100
120
140
160
170
TIME (MIN.)

Fig. 4-3

5. CONCLUSIONS

The results of both the subsystem and system level testing demonstrated that the MA-010 prototype MEF System characteristics met all the design goals for the equipment. At the conclusion of the test sequence, it was found that unanticipated deformation had occurred in the spacer (gradient) tubes. Subsequent analysis* revealed that this problem arose from tolerance build-up which caused mechanical interference at high operating temperatures and this problem has been corrected in the flight design.

Under an addendum to this contract, the feasibility of constructing a flight-qualified pulser unit for experiment MA-060 was established.

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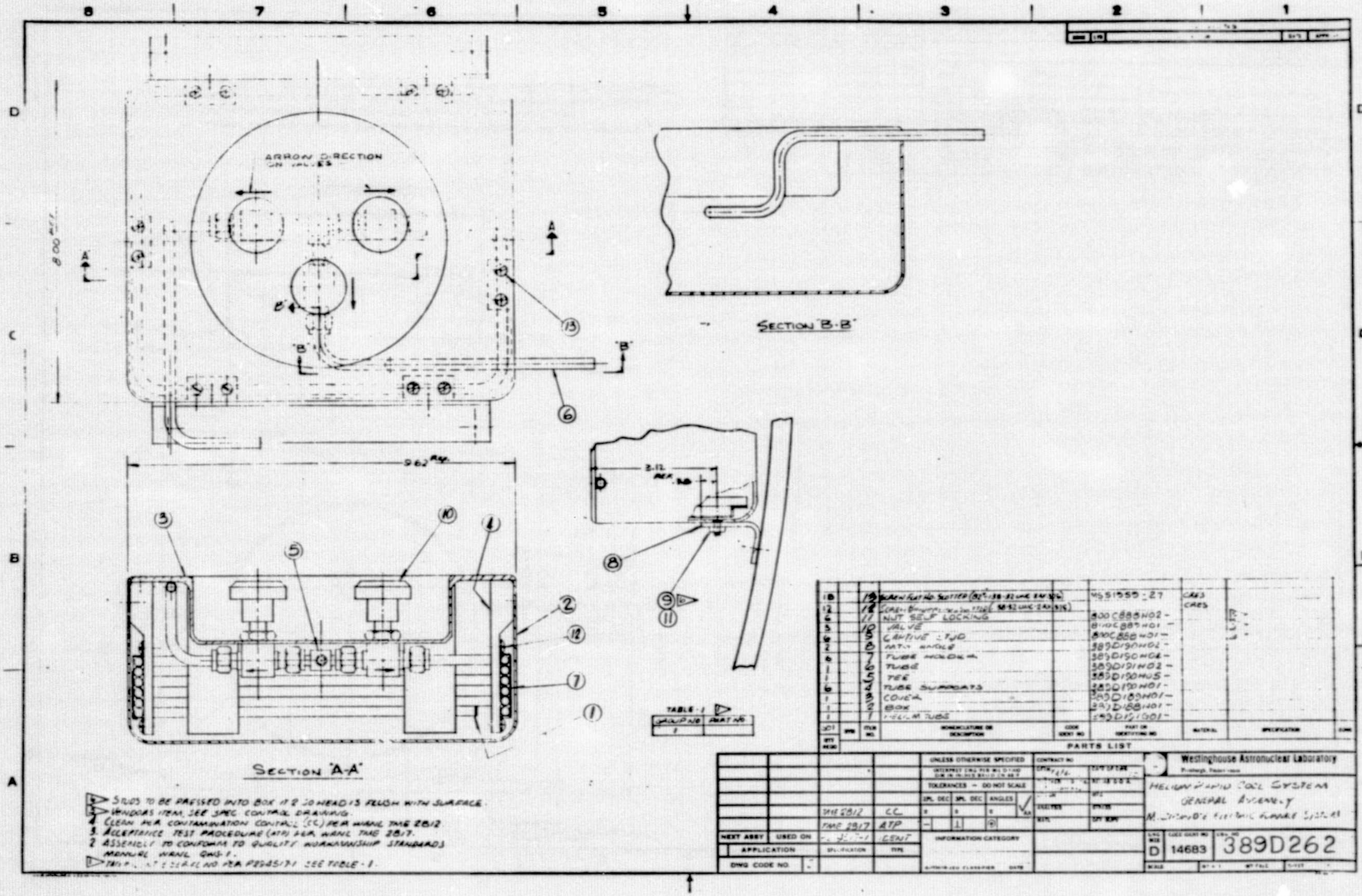
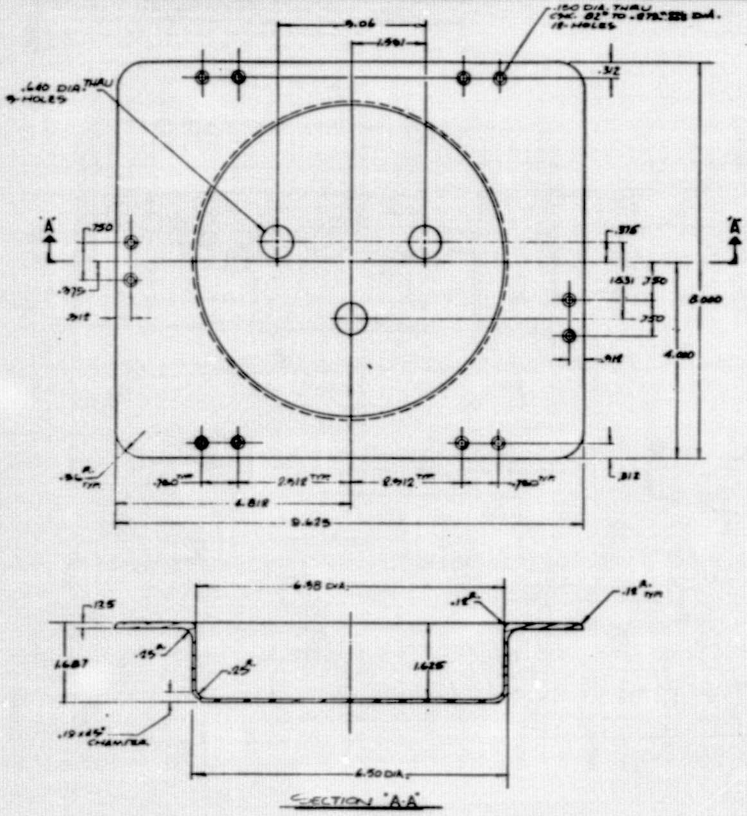
*(WANL DRM Nos. DA-0112 and DA-0114.)

APPENDIX A -- NEW OR MODIFIED DETAIL DESIGN DRAWINGS FOR MA-010 FURNACE AND HELIUM PACKAGE


ARROW DIRECTION ON VALVES
SECTION "B-B"
SECTION "A-A"
TABLE-1
GROUP NO
PART NO
STUDS TO BE PRESSED INTO BOX SO HEAD IS FLUSH WITH SURFACE.
VENDORS ITEM, SEE SPEC CONTROL DRAWING.
4. CLEAN PER CONTAMINATION CONTROL (CC) PER WANL TME 2812
3. ACCEPTANCE TEST PROCEDURE (ATP) PER WANL TME 2817.
2. ASSEMBLY TO CONFORM TO QUALITY WORKMANSHIP STANDARDS MANUAL WANL QMS-1.
SEE TABLE-1.
NUT SELF LOCKING
VALVE
TUBE HOLDER
TUBE
TEE
TUBE SUPPORTS
COVER
BOX
HELIUM TUBE
MS51959-27
CRES
800C888H02
389D190H02
389D190H04
389D191H02
389D190H05
389D190H01
389D189H01
389D188H01
PARTS LIST
UNLESS OTHERWISE SPECIFIED
TOLERANCES — DO NOT SCALE
ANGLES
TME 2812
CC
TME 2817
ATP
NEXT ASSY
USED ON
APPLICATION
SPECIFICATION
TYPE
DWG CODE NO.
INFORMATION CATEGORY
CONTRACT NO
Westinghouse Astronuclear Laboratory
HELIUM RAPID COOL SYSTEM
GENERAL ASSEMBLY
D
14683
389D262



SECTION "A-A"

3. ANODIZE PER MIL-A-8625 TYPE 2, DYE GRAY COLOR NO. 36231 PER FED-STD-595.
2. TAG PART NUMBER & SERIAL NO. PER PE84517-1 SEE IDENT. COL.
1. UNLESS OTHERWISE SPECIFIED REMOVE ALL BURRS & BREAK ALL SHARP EDGES .010 MAX. R. OR CHAM. INTERNAL CORNERS SHALL HAVE FILLETS OF .010 MAX. R.

PARTS LIST

QTY REQD		FIND NO.	NOMENCLATURE OR DESCRIPTION	CODE IDENT NO.	PART OR IDENTIFYING NO.	MATERIAL	SPECIFICATION
		1	COVER		389D189		

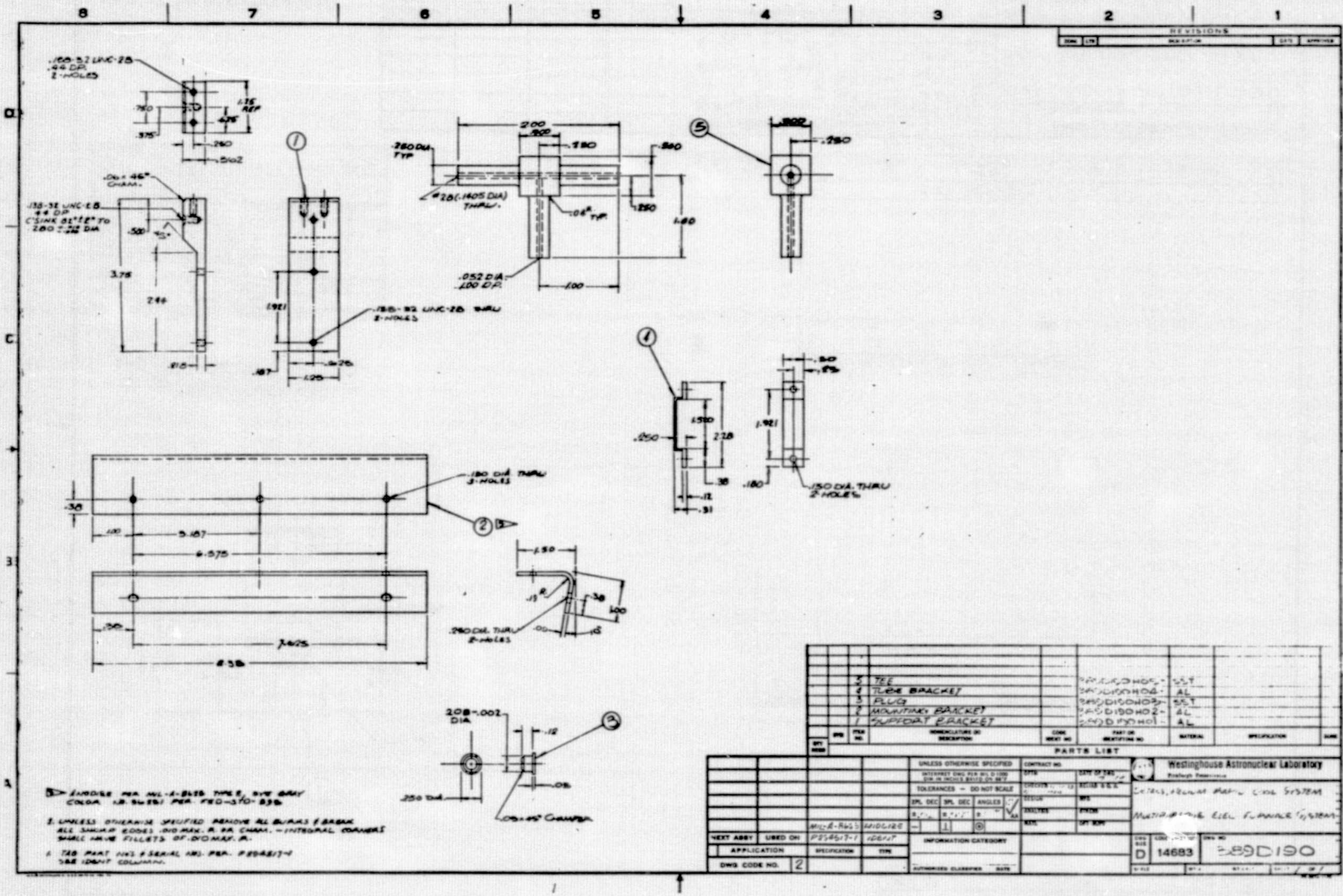
NEXT ASSY	USED ON
APPLICATION	
DWG CODE NO.	2

UNLESS OTHERWISE SPECIFIED
TOLERANCES — DO NOT SCALE

Westinghouse Astronuclear Laboratory

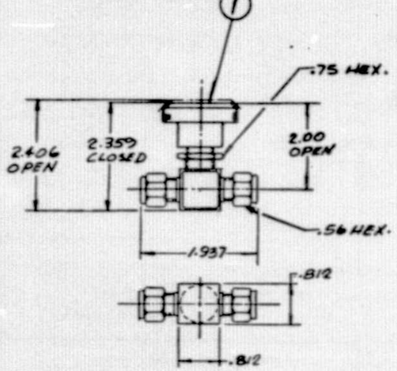
MULTIPURPOSE ELEC. FURNACE SYSTEM

SIZE	CODE IDENT NO.	DWG NO.
D	14683	389D189



REVISIONS
.138-32 UNC-2B .44 DP. 2-HOLES
.750
.375
.250
.502
1.75 REF
.06 x 45° CHAM.
.138-32 UNC-2B .44 DP C'SINK 82°±2° TO .280 DIA
.500
3.75
2.44
.218
1.921
.138-32 UNC-2B THRU 2-HOLES
.187
1.25
2.00
.900
.250 DIA TYP
.180
.500
#28 (.1405 DIA) THRU.
.06 R TYP.
.250
1.80
.052 DIA .100 DP.
1.00
.500
.250
.250
1.500
2.28
.38
.12
.31
1.921
.180
.130 DIA THRU 2-HOLES
.130 DIA THRU 3-HOLES
.38
.100
3.187
6.375
.150
7.625
8.38
1.50
.13 R
.38
1.00
.250 DIA THRU 2-HOLES
.15
.208-.002 DIA
.12
.05
.250 DIA
.05 x 45° CHAMFER
ANODIZE PER MIL-A-8625 TYPE II, DYE GRAY COLOR NO. 36251 PER FED-STD-595
2. UNLESS OTHERWISE SPECIFIED REMOVE ALL BURRS & BREAK ALL SHARP EDGES .010 MAX. R OR CHAM. - INTERNAL CORNERS SHALL HAVE FILLETS OF .010 MAX. R.
1. TAG PART NOS & SERIAL NOS PER PS 24517-1 SEE IDENT COLUMN.
5 TEE
4 TUBE BRACKET
3 PLUG
2 MOUNTING BRACKET
1 SUPPORT BRACKET
AL
SST
ITEM NO.
NOMENCLATURE OR DESCRIPTION
MATERIAL
SPECIFICATION
PARTS LIST
UNLESS OTHERWISE SPECIFIED
TOLERANCES — DO NOT SCALE
ANGLES
CONTRACT NO.
Westinghouse Astronuclear Laboratory
MIL-A-8625 ANODIZE
PS 24517-1 IDENT
NEXT ASSY
USED ON
APPLICATION
SPECIFICATION
TYPE
DWG CODE NO. 2
INFORMATION CATEGORY
AUTHORIZED CLASSIFIER
DATE
D
14683
389D190

REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROVED



SUGGESTED SOURCE(S) OF SUPPLY		
ITEM NO.	VENDOR	VENDOR'S PART NO.
1	NUPRO COMPANY 15635 SARANAC ROAD CLEVELAND, OHIO 44110	SS-4H

TABLE-1 DIMENSIONS

TUBE SIZE	INLET & OUTLET	PORT ORIFICE
.250	.25 SWAGELOK	.156 DIA.

SPECIFICATION CONTROL DRAWING

TABLE-2 MATERIALS

PART	MATERIAL
STEM	316L STAINLESS STEEL
STEM INSERT	HARDENED 17-4PH SST
BELLOWS	321 SST (SEAMLESS)
RETAINING RING	15-7 MO. SST.
RING	316 SST
SPRING	17-7 PH HIGHTENSILE SST.
BODY-BONNET	316L SST
PIN	420 PASSIVATED SST.
CAP	AL, ANODIZED HUNTER GRN.
ALL OTHER PARTS	316 SST.

QTY REQD	SYM	ITEM NO.	NOMENCLATURE OR DESCRIPTION	CODE IDENT NO.	PART OR IDENTIFYING NO.	MATERIAL	SPECIFICATION	ZONE
		1	VALVE		800C889H01 –			

PARTS LIST

1 TAG IDENT PART NO. & SERIAL NUMBER PER P294517-1, SEE IDENT COLUMN.

NEXT ASSY	USED ON	P-294517-1	IDENT
APPLICATION		SPECIFICATION	TYPE
DWG CODE NO.	2		

UNLESS OTHERWISE SPECIFIED
INTERPRET DWG PER MIL-D-1000
DIM IN INCHES BASED ON 68°F
TOLERANCES — DO NOT SCALE

2PL DEC	3PL DEC	ANGLES
±.[illegible]	±.[illegible]	±.[illegible]

125 AA

INFORMATION CATEGORY
AUTHORIZED CLASSIFIER — DATE

CONTRACT NO.	
DFTM J. Adams	DATE OF DWG [illegible]
CHECKER 12-14-73 W. Simpman	RELIAB & Q.A.
DESIGN	MFG
ANALYSIS	STRESS
MATL	DFT SUPV

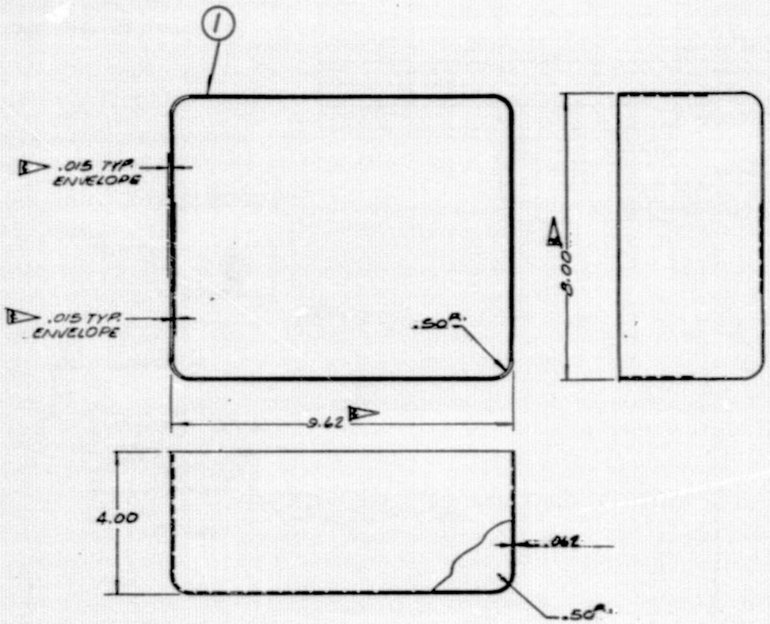
Westinghouse Astronuclear Laboratory
Pittsburgh, Pennsylvania

VALVE, HELIUM RAPID COOL SYSTEM
MULTIPURPOSE ELEC. FURNACE SYSTEM

DWG SIZE	CODE IDENT NO.	DWG NO.
C	14683	800C889

SCALE | WT ACT | WT CALC | SHEET OF

REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROVED



SUGGESTED SOURCE(S) OF SUPPLY		
ITEM NO.	VENDOR	VENDORS PART NO.
1	ZERO MANUFACTURING Co. 288 MAIN STREET MONSON, MASS. 01057	Z128-154A

SPECIFICATION CONTROL DWG.

800C887

▷ THESE ARE INTERFACE CONTROL DIMENSIONS AND CAN NOT BE CHANGED WITHOUT PRIOR APPROVAL OF PROJECT MANAGER.

▷ BOX MUST FALL WITHIN THE ENVELOPE AS DEFINED FOR THE TOTAL LENGTH, WIDTH & DEPTH.

1. MARK CONTAINER WITH VENDORS PART NO. & WANL ITEM & DWG. NO. SEE IDENT COLUMN.

QTY REQD	SYM	ITEM NO.	NOMENCLATURE OR DESCRIPTION	CODE IDENT NO.	PART OR IDENTIFYING NO.	MATERIAL	SPECIFICATION	ZONE
		1	BOX			AL 6061-0		

PARTS LIST

NEXT ASSY	USED ON		
P.11517-1	IDENT		
APPLICATION		SPECIFICATION	TYPE
DWG. CODE NO.	2		

UNLESS OTHERWISE SPECIFIED
INTERPRET DWG PER MIL-D-1000
DIM IN INCHES BASED ON 68°F
TOLERANCES — DO NOT SCALE

2PL DEC	3PL DEC	ANGLES
±.02	±.010	±.5°

INFORMATION CATEGORY

AUTHORIZED CLASSIFIER DATE

CONTRACT NO.	
DFTM J. Nanns	DATE OF DWG 7-7-72
CHECKER	RELIAB & Q. A.
DESIGN	MFG
ANALYSIS	STRESS
MATL	DPT SUPV

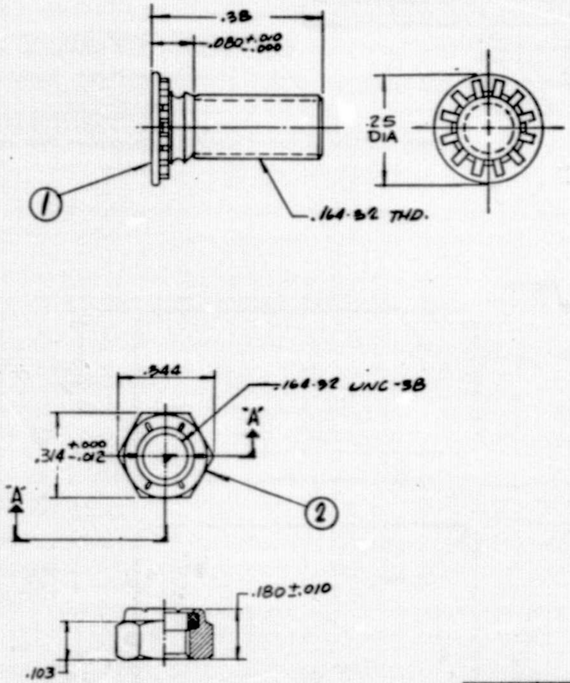
Westinghouse Astronuclear Laboratory
Pittsburgh, Pennsylvania

BOX, HELIUM RAPID COOL SYSTEM
MULTIPURPOSE ELEC. FURNACE SYSTEM

DWG SIZE	CODE IDENT NO.	DWG NO.
C	14683	800C887

SCALE | WT ACT. — | WT CALC | SHEET 1 OF

REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPR



SECTION 'A-A'

SUGGESTED SOURCE(S) OF SUPPLY		
ITEM NO.	VENDOR	VENDORS PART NO.
1	PENN ENGINEERING & MANUFACTURING CORP. DOYLESTOWN, PA., 18901	FHS-832-6
2	ELASTIC STOP NUT DIV. 2330 VAUXHALL ROAD, UNION, NEW JERSEY, 07083	79NM40B-82

SPECIFICATION CONTROL DWG.

2. ALL DIMENSIONS ARE REFERENCE.

1. TAG IDENT PART NO. & SERIAL NUMBER PER. P894517-1, SEE IDENT COLUMN.

QTY REQD	SYM	ITEM NO.	NOMENCLATURE OR DESCRIPTION	CODE IDENT NO.	PART OR IDENTIFYING NO.	MATERIAL	SPECIFICATION	ZONE
		2	NUT, REDUCED HEX.			SST.	AISI-303	
		1	STUD-FLUSH HEAD			SST.		

PARTS LIST

NEXT ASSY	USED ON
P894517-1	IDENT
APPLICATION	
SPECIFICATION	TYPE

DWG CODE NO.

UNLESS OTHERWISE SPECIFIED
INTERPRET DWG PER MIL-D-1000
DIM IN INCHES BASED ON 68°F
TOLERANCES — DO NOT SCALE

2PL DEC	3PL DEC	ANGLES
±.02	±.005	±.5°

125 AA

INFORMATION CATEGORY

AUTHORIZED CLASSIFIER DATE

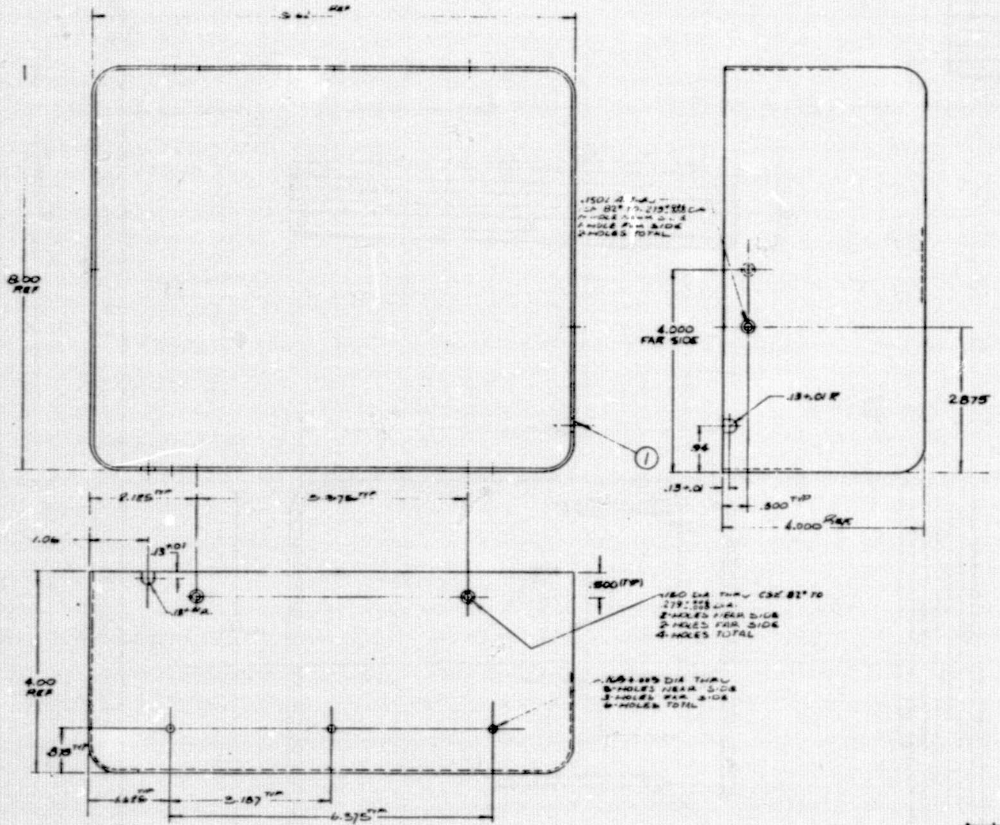
CONTRACT NO.	
DFTM J. MARKS	DATE OF DWG 12-7-73
CHECKER 12-13-73 W. SUMPMAN	RELIAB & Q. A.
DESIGN	MFG
ANALYSIS	STRESS
MATL	DPT SUPV

Westinghouse Astronuclear Laboratory
Pittsburgh, Pennsylvania

STUD & NUT HELIUM RADIO COOL SYSTEM
MULTIPURPOSE ELEC. FURNACE SYSTEM

DWG SIZE	CODE IDENT NO.	DWG NO.
C	14683	800C888

SCALE WT ACT. WT CALC SHEET OF



ANODIZE PER MIL-A-8625 TYPE 2, DYE GRAY COLOR No. 36231 PER FED-STD-595.

3. TAG PART NUMBER & SERIAL NO. PER P294517-1 SEE IDENT. COLUMN.

2. UNLESS OTHERWISE SPECIFIED REMOVE ALL BURRS & BREAK ALL SHARP EDGES .010 MAX. R. OR CHAM. - INTERNAL CORNERS SHALL HAVE FILLETS OF .010 MAX. R.

VENDOR ITEM - SEE SPECIFICATION CONTROL DWG. 800C887

		1	BOX		359D188H01 -	800C887 ITEM 1	
QTY REQD	SYM	ITEM NO	NOMENCLATURE OR DESCRIPTION	CODE IDENT NO	PART OR IDENTIFYING NO	MATERIAL	SPECIFICATION

PARTS LIST

		MIL-A-8625	ANODIZE
NEXT ASSY	USED ON	P294517-1	IDENT
APPLICATION		SPECIFICATION	TYPE
DWG CODE NO.			

UNLESS OTHERWISE SPECIFIED
INTERPRET DWG PER MIL-D-1000
DIM IN INCHES BASED ON 68°F
TOLERANCES — DO NOT SCALE

2PL DEC	3PL DEC	ANGLES
±.02	±.005	±.5°

INFORMATION CATEGORY
AUTHORIZED CLASSIFIER DATE

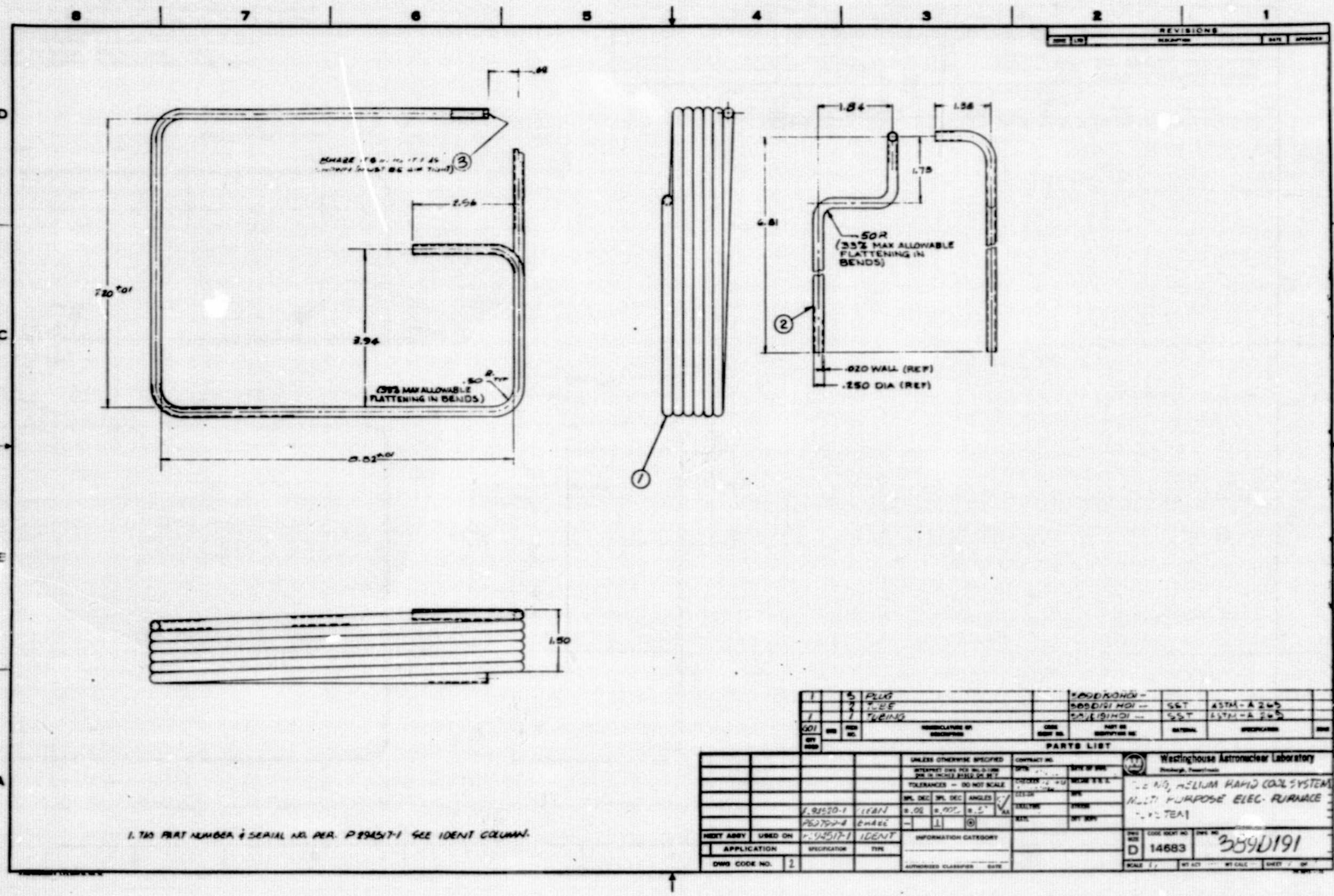
CONTRACT NO
DFTR | DATE OF ISSUE
CHECKER | RELEASE N.D.R.
DESIGN | MFG
ANALYSIS | SYSTEM
SUPV | OPT SUPV

Westinghouse Astronuclear Laboratory
Pittsburgh, Pennsylvania

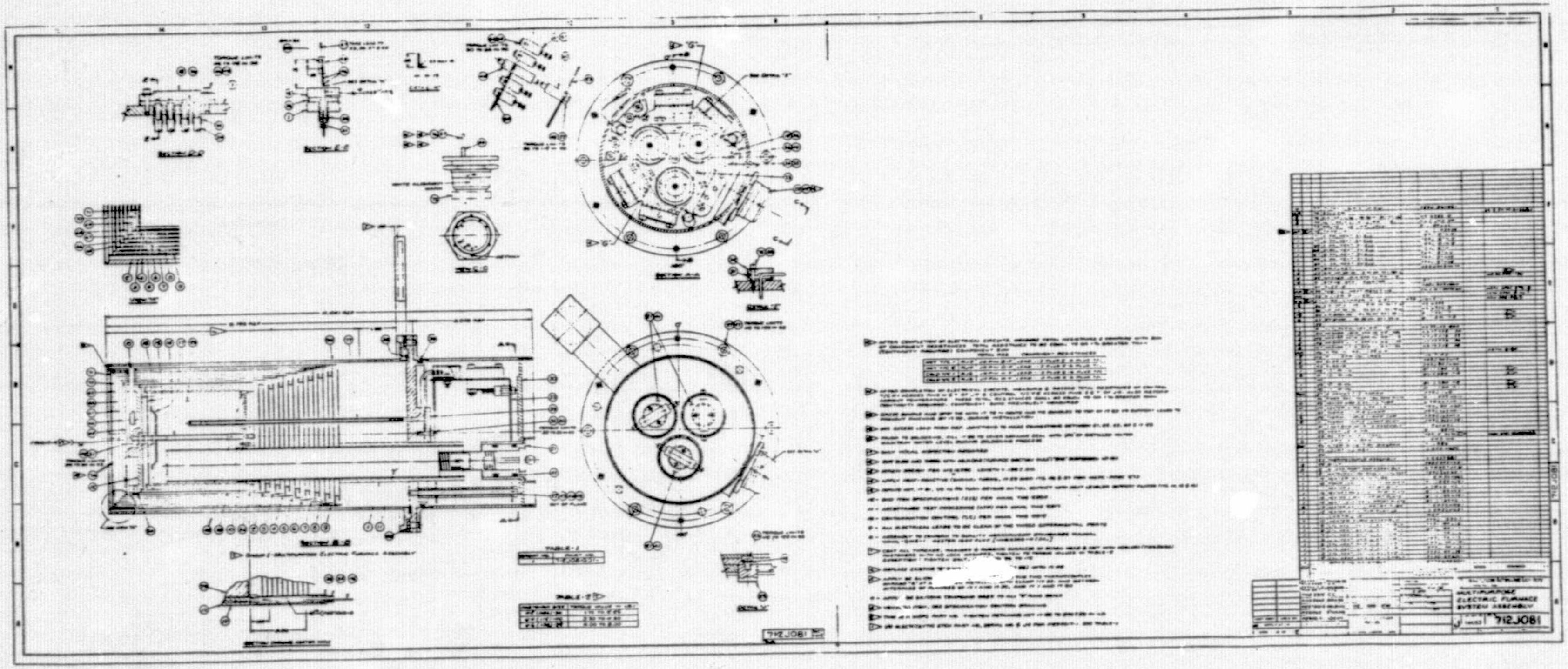
ELEC FURNACE

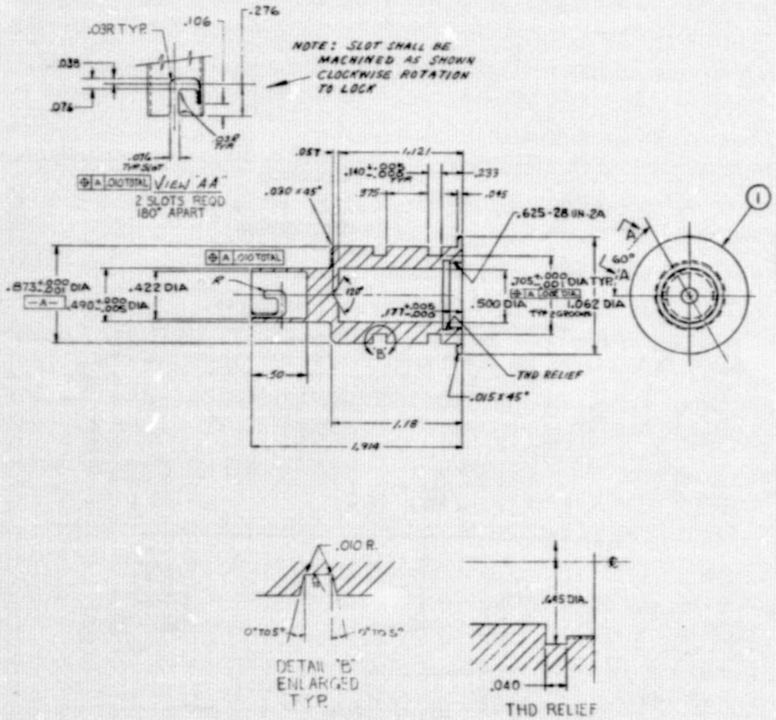
DWG SIZE	CODE IDENT NO	DWG NO
D	14683	359D188

SCALE 1/1 WT ACT — WT CALC SHEET 1 OF 1


REVISIONS
.04
1.84
1.38
1.75
6.81
.50R
(33% MAX ALLOWABLE FLATTENING IN BENDS)
2.56
3.94
(33% MAX ALLOWABLE FLATTENING IN BENDS)
.020 WALL (REF)
.250 DIA (REF)
1.50
PLUG
TUBE
TUBING
SST
ASTM-A 265
PARTS LIST
Westinghouse Astronuclear Laboratory
HELIUM RAPID COOL SYSTEM
MULTI PURPOSE ELEC. FURNACE
UNLESS OTHERWISE SPECIFIED
TOLERANCES — DO NOT SCALE
CLEAN
BRAZE
IDENT
NEXT ASSY
USED ON
APPLICATION
DWG CODE NO. 2
INFORMATION CATEGORY
D
14683
389D191
1. TAG PART NUMBER & SERIAL NO. PER P894517-1 SEE IDENT COLUMN.

712J081





4 – UNLESS OTHERWISE SPECIFIED FEATURES SHOWN COAXIAL TO DATUM [A] ARE [⊕|A|.006 DIA]

3 – TAG IDENT PART NO. & SERIAL NO. PER P294517-1. SEE IDENT COLUMN.

2 – UNLESS OTHERWISE SPECIFIED REMOVE ALL BURRS AND BREAK ALL SHARP EDGES .010 MAX RADIUS OR CHAMFER. INTERNAL CORNERS .010 MAX R.

1 – THIS DRAWING REPLACES R&D DRAWING 723B612.

PARTS LIST

QTY REQD	SYM	ITEM NO.	NOMENCLATURE OR DESCRIPTION	CODE IDENT NO.	PART OR IDENTIFYING NO.	MATERIAL	SPECIFICATION	ZONE
		1	CAP, ACCESS PORT		389D279H01-	CRES	AMS 5639	

NEXT ASSY	USED ON		
		P294517-1	IDENT
G	APPLICATION	SPECIFICATION	TYPE
DWG CODE NO. 2			

UNLESS OTHERWISE SPECIFIED
INTERPRET DWG PER MIL-D-1000
DIM IN INCHES BASED ON 68°F
TOLERANCES – DO NOT SCALE

2PL DEC	3PL DEC	ANGLES	
±.02	±.005	±0°30'	125/ AA

INFORMATION CATEGORY: NU
AUTHORIZED CLASSIFIER — DATE 2/1/74

CONTRACT NO. XAL-71576
DFTR: MACRAY — DATE OF DWG: 2-18-74

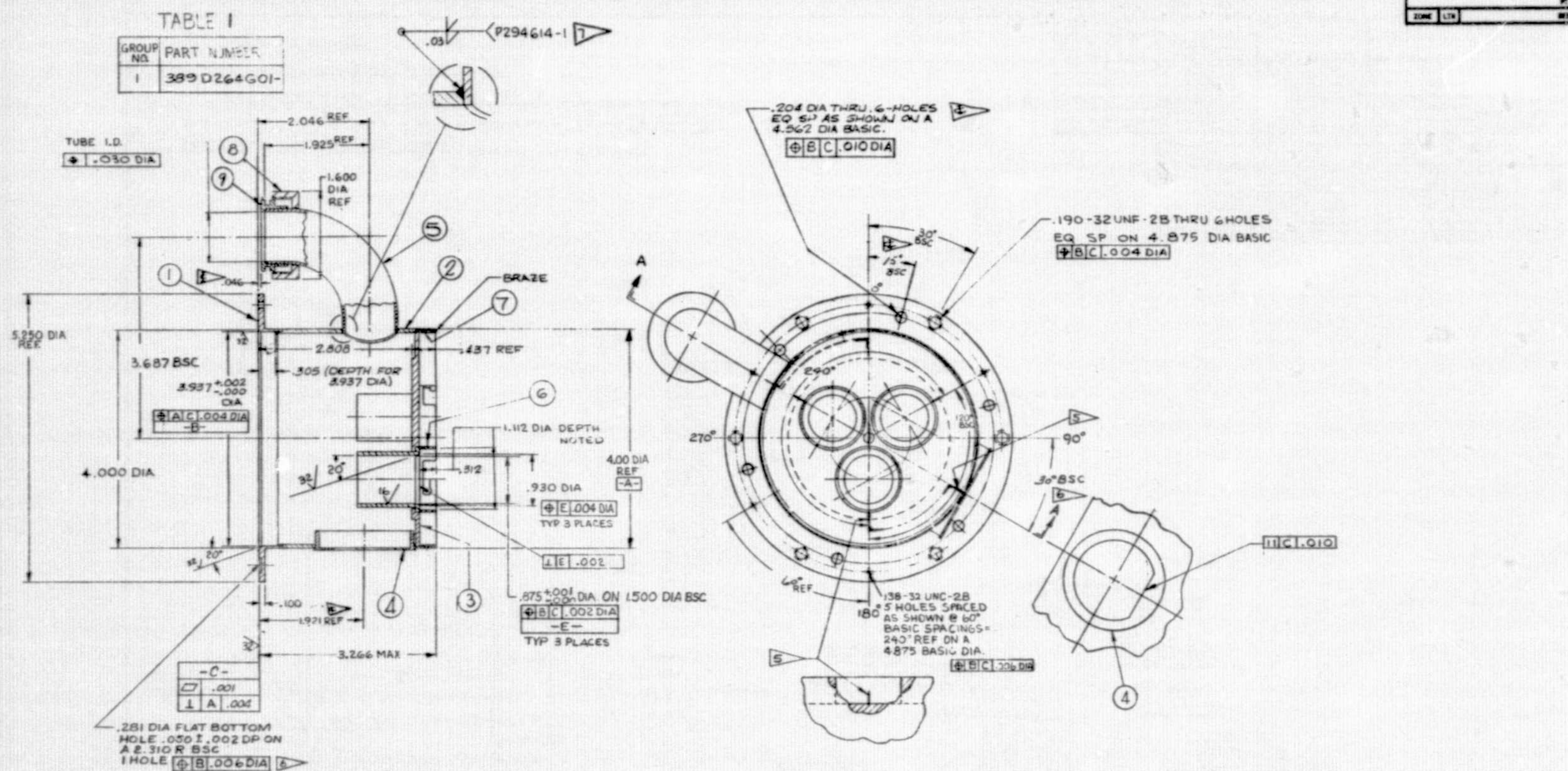
Westinghouse Astronuclear Laboratory
Pittsburgh, Pennsylvania

CAP, ACCESS PORT
INSTRUMENT CHAMBER
MULTIPURPOSE ELECTRIC FURNACE SYSTEM

DWG SIZE	CODE IDENT NO.	DWG NO.
D	14683	389D279

SCALE 2/1 — WT ACT. — WT CALC — SHEET OF

389D279



9. ASSY TO BE LEAK TESTED PER PS 294502
8. PARTS & ASSY TO BE CLEANED PER PS294520-1
7. PERFORM LIQUID PENETRANT INSPECTION PER P294564-1, CLASS O.
6. LOCATION OF HOLE FOR KEY SCREW.
6. THESE ARE INTERFACE CONTROL DIMENSIONS AND CANNOT BE CHANGED WITHOUT PRIOR APPROVAL OF PROGRAM MANAGER.
5. MATCH SCRIBE LINE ON ITEM 2 & 3 AND SCRIBE LINES ON ITEM 6 & 3 (3 PLACES) WITHIN .010 TOTAL BEFORE BRAZING.
4- COPPER FURNACE BRAZE ALL JOINTS VACUUM TIGHT PER PS97994-1.
3- UNLESS OTHERWISE SPECIFIED FEATURES SHOWN COAXIAL TO DATUM -B- ARE ⊕ B .006 DIA
2- TAG IDENT PART NUMBER AND SERIAL NUMBER PER P294517-1 SEE IDENT COL.
1- UNLESS OTHERWISE SPECIFIED, REMOVE ALL BURRS & BREAK ALL SHARP EDGES .010 MAX R OR CHAMFER. INTERNAL CORNERS .010 R MAX.

QTY REQD G01	SYM	ITEM NO.	NOMENCLATURE OR DESCRIPTION	CODE IDENT NO.	PART OR IDENTIFYING NO.	MATERIAL	SPECIFICATION	ZONE
1		9	FLANGE		800C897-01-			
1		8	NUT		800C897-02-			
1		7	RING		101E430-2E			
3		6	ACCESS PORT		101E430-09-			
1		5	ELBOW, MODIFIED		389D186-09-			
1		4	BOSS, RECEPTACLE		101E430-11-			
1		3	CAP		101E430HO2B			
1		2	TUBE		800C850-01A			
1		1	FLANGE		101E430HO1A			

PARTS LIST

	P294564	PENETRANT
	P294614	WELD
	P294520	CLEANING
	P294502	HELIUM LEAK TEST
AS.T.R	P597994	BRAZE
NEXT ASSY	USED ON	
APPLICATION	SPECIFICATION	TYPE

DWG CODE NO. 2

UNLESS OTHERWISE SPECIFIED
INTERPRET DWG PER MIL-D-1000
DIM IN INCHES BASED ON 68°F
TOLERANCES — DO NOT SCALE
2PL DEC ±.02 3PL DEC ±.005 ANGLES ±0°30'

INFORMATION CATEGORY

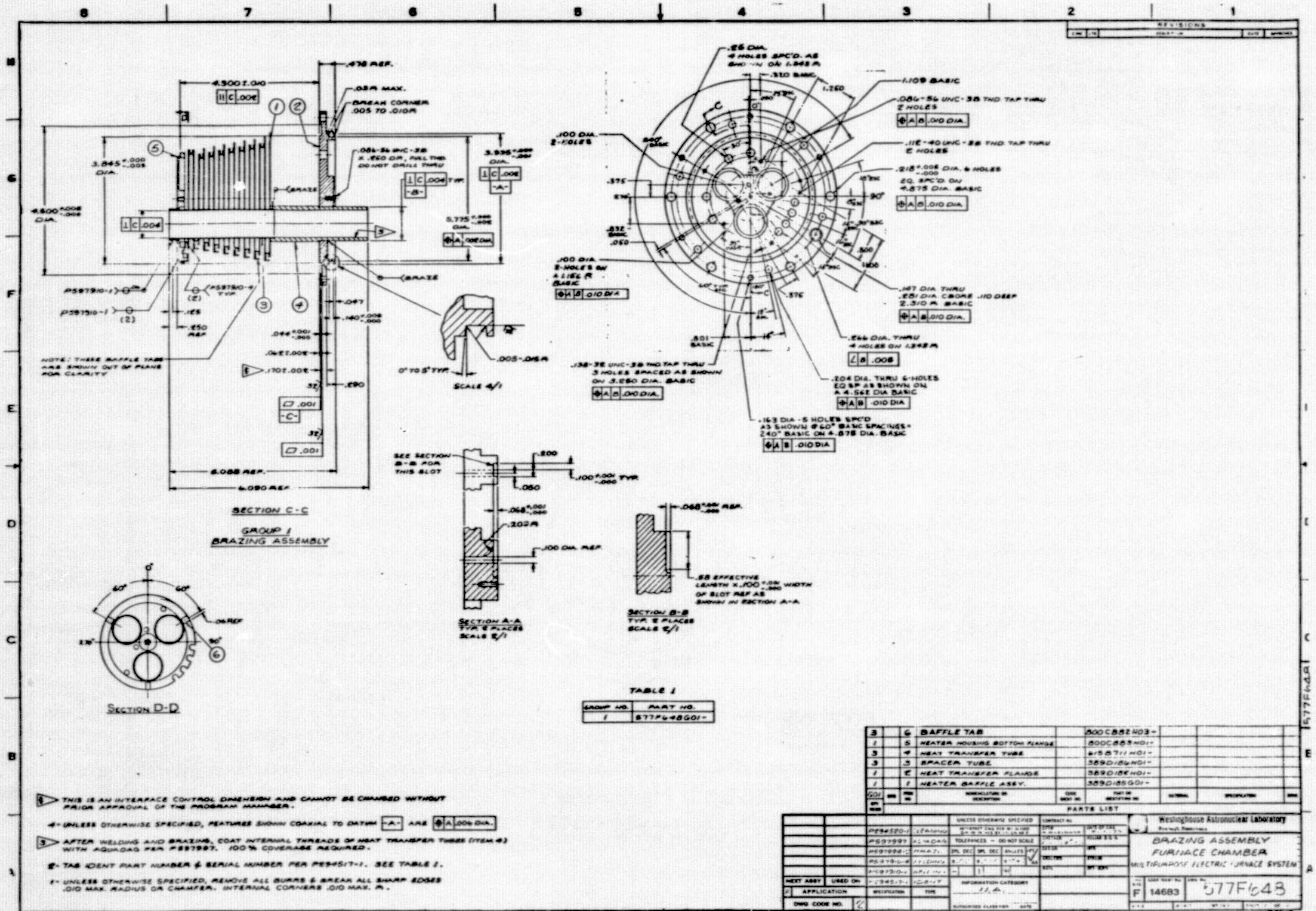
CONTRACT NO. XAL-71576
DFTR M. VOJISIK DATE OF ISSUE 2-4-74

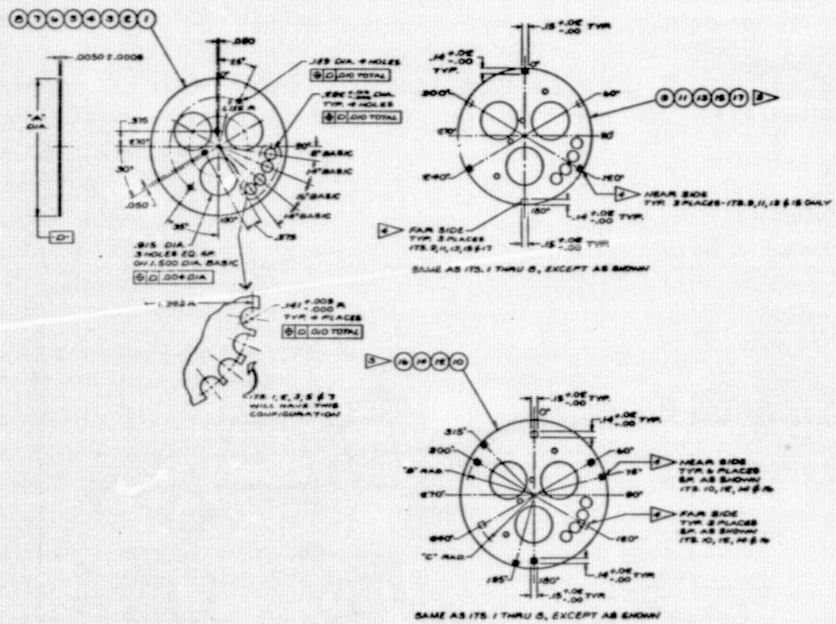
Westinghouse Astronuclear Laboratory
Pittsburgh, Pennsylvania

INSTRUMENT CHAMBER HOUSING ASSY
MULTIPURPOSE ELEC FURNACE SYS

SIZE D | CODE IDENT NO. 14683 | DWG NO. 389D264

389D264


SECTION C-C
GROUP 1
BRAZING ASSEMBLY
SECTION D-D
SECTION A-A
TYP. 2 PLACES
SCALE 2/1
SECTION B-B
TYP. 2 PLACES
SCALE 2/1
SCALE 4/1
TABLE 1
GROUP NO. | PART NO.
1 | 577F648G01-
THIS IS AN INTERFACE CONTROL DIMENSION AND CANNOT BE CHANGED WITHOUT PRIOR APPROVAL OF THE PROGRAM MANAGER.
4- UNLESS OTHERWISE SPECIFIED, FEATURES SHOWN COAXIAL TO DATUM -A- ARE A .006 DIA.
AFTER WELDING AND BRAZING, COAT INTERNAL THREADS OF HEAT TRANSFER TUBES (ITEM 4) WITH AQUADAG PER PS97997. 100% COVERAGE REQUIRED.
2- TAG IDENT PART NUMBER & SERIAL NUMBER PER PS94517-1. SEE TABLE 1.
1- UNLESS OTHERWISE SPECIFIED, REMOVE ALL BURRS & BREAK ALL SHARP EDGES .010 MAX. RADIUS OR CHAMFER. INTERNAL CORNERS .010 MAX. R.
3 | 6 | BAFFLE TAB | 800C882H03-
1 | 5 | HEATER HOUSING BOTTOM FLANGE | 800C883H01-
3 | 4 | HEAT TRANSFER TUBE | 615B711H01-
3 | 3 | SPACER TUBE | 389D186H01-
1 | 2 | HEAT TRANSFER FLANGE | 389D182H01-
1 | 1 | HEATER BAFFLE ASSY. | 389D185G01-
PARTS LIST
UNLESS OTHERWISE SPECIFIED
TOLERANCES — DO NOT SCALE
INFORMATION CATEGORY
Westinghouse Astronuclear Laboratory
BRAZING ASSEMBLY
FURNACE CHAMBER
MULTIPURPOSE ELECTRIC FURNACE SYSTEM
F
14683
577F648



ITEM	"A" DIA.	"B" RAD	"C" RAD
1	2.996 [illegible]		
2	2.996 [illegible]		
3	2.75		
4	3.104 [illegible]		
5	2.85		
6	3.212 [illegible]		
7	2.96		
8	3.320 [illegible]		
9	3.07		
10	3.428 [illegible]	1.59	1.54
11	3.18		
12	3.536 [illegible]	1.64	1.59
13	3.29		
14	3.644 [illegible]	1.70	1.64
15	3.39		
16	3.752 [illegible]	1.75	1.70
17	3.50		

4 REMOVE GOLD PLATING PER PS97893 FROM SURFACE INDICATED.

3 BAFFLE PLATES ITS. 9 THRU 17 SHALL BE GOLD PLATED TO .0002 ±.0001 THICK PER PS97893, AND POLISHED TO A BRIGHT METALLIC FINISH.

2- UNLESS OTHERWISE SPECIFIED, REMOVE ALL BURRS AND BREAK ALL SHARP EDGES .001 MAX. RADIUS OR CHAMFER.

1- TAG IDENT PART NUMBER AND SERIAL NUMBER PER PS94817-1 SEE IDENT COLUMN.

		ITEM NO	NOMENCLATURE OR DESCRIPTION	CODE IDENT NO	PART OR IDENTIFYING NO	MATERIAL	SPECIFICATION	
		17	BAFFLE PLATE		577F647N017	MO	AMS 7800	
		16	BAFFLE PLATE		577F647N016	MO	[illegible]	
		15	BAFFLE PLATE		577F647N015	MO	[illegible]	
		14	BAFFLE PLATE		577F647N014	MO	AMS 7800	
		13	BAFFLE PLATE		577F647N013	MO	AMS 7800	
		12	BAFFLE PLATE		577F647N012	MO	AMS 7800	
		11	BAFFLE PLATE		577F647N[illegible]	MO	[illegible]	
		10	BAFFLE PLATE		577F647N[illegible]	MO	[illegible]	
		9	BAFFLE PLATE		577F647N09	MO	[illegible]	
		8	BAFFLE PLATE		577F647N08	MO	AMS 7800	
		7	BAFFLE PLATE		577F647N07	MO	[illegible]	
		6	BAFFLE PLATE		577F647N06	MO	[illegible]	
		5	BAFFLE PLATE		577F647N05	MO	[illegible]	
		4	BAFFLE PLATE		577F647N04	MO	[illegible]	
		3	BAFFLE PLATE		577F647N03	MO	[illegible]	
		2	BAFFLE PLATE		577F647N02	MO	[illegible]	
		1	BAFFLE PLATE		577F647N01	MO	AMS 7800	

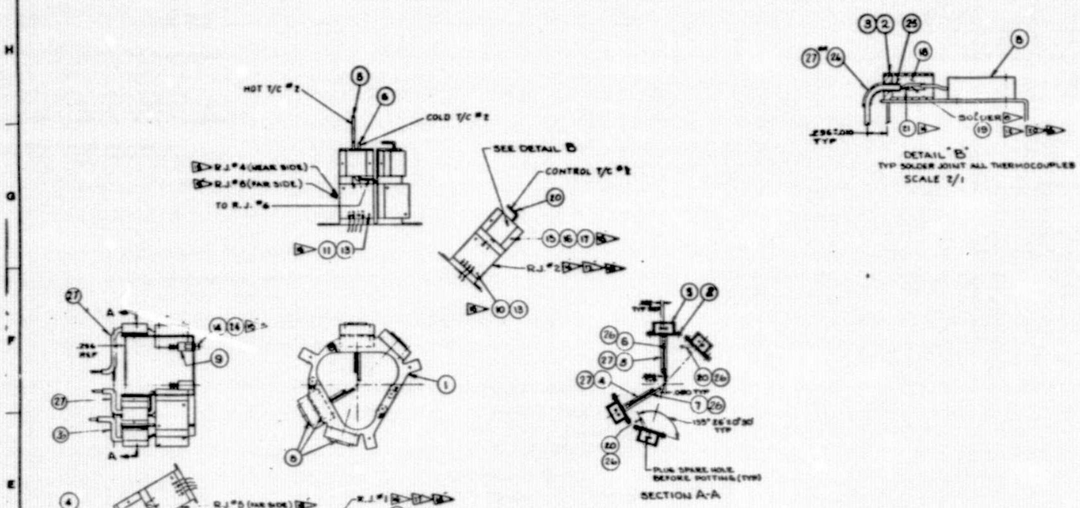
PARTS LIST

Westinghouse Astronuclear Laboratory

BAFFLE PLATE
FURNACE CHAMBER

F | 14683 | 577F647

NEXT ASSY | USED ON
APPLICATION



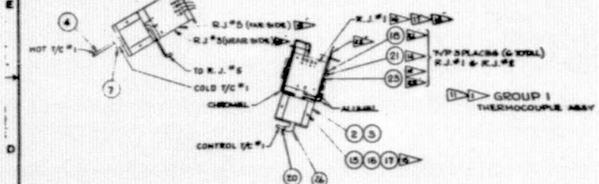


TABLE 1

GROUP NO	PART NO.
1	1015437G01

- AFTER TRIMMING LEADS 1 & 2 TO LENGTH MEASURE & RECORD RESISTANCE ON RJ3, 4, 5 & 6 ACROSS LEADS 1 & 2 AND ACROSS LEADS 5 & 6. RECORD AMBIENT TEMPERATURE.
- MEASURE & RECORD RESISTANCE OF RJ1 & RJ2 BETWEEN LEADS 5 & 6. ALSO RECORD AMBIENT TEMPERATURE.
- MEASURE AND RECORD RESISTANCE OF CHROMEL & ALUMEL WIRES PRIOR TO SPLICING INTO CONTROL T/C CIRCUIT. MEASURE & RECORD RESISTANCE OF CONTROL T/C 1 & 2 CIRCUITS AFTER ADDITION OF CHROMEL & ALUMEL SPLICED WIRE BEFORE & AFTER POTTING. RESISTANCE SHALL BE +1% −0% OF THE SUM OF T/C AND WIRE SPLICE RESISTANCES.
- CUT LEADS 1, 3 & 4 ON REFERENCE JUNCTIONS (RJ#1 & RJ#2) FLUSH WITH IT 8 APPLY IT 18 TO EXPOSED LEAD END.
- TORQUE ITEMS 14 – 30 TO 40 IN-LBS MAX. TORQUE ITEM 15 – RUNNING TORQUE PLUS 45 TO 55 INCH-LBS MAX. TORQUE ITEM 10 & 11 – RUNNING TORQUE PLUS 30 TO 34 IN-LBS MAX.
- SLIP ITEM 21 OVER EACH WIRE BEFORE SOLDERING. AFTER SOLDERING, PLACE IN POSITION AND INSTALL PER MSFC-PROC-273
- THE ASSEMBLED T/C POT SHALL BE FILLED WITH ITEM 18 AND CURED PER VENDOR SUPPLIED INSTRUCTIONS.
- SOLDER REF JUNCTIONS LEADS IT 19 PER WANL QWS-1. KESTER 1544 FLUX [NHB 5300-4 (3A)] MAY BE USED EXCEPT AS INDICATED IN NOTE 6.

11 — COAT ALL THREADS, WASHERS & RUBBING SURFACES OF SCREW HEADS AND NUT WITH NEOLUBE (POS 9145)

10 — ASSEMBLY TO CONFORM TO QUALITY WORKMANSHIP STANDARDS MANUAL WANL-QWS-1 (WESTINGHOUSE ASTRONUCLEAR LABORATORY).

- SOLDER CHROMEL WIRE TO CHROMEL WIRE & ALUMEL WIRE TO ALUMEL WIRE WITH HOOK SPLICE. ALUMEL WIRES ARE FERROMAGNETIC & GLOSSY. CHROMEL WIRES ARE NON MAGNETIC & DULL.
- TIN ALL CHROMEL AND ALUMEL WIRES WITH ITEM 19. USE OF KESTER-TYPE 815 SOLDERING FLUX IS PERMITTED. FLUX MUST BE THOROUGHLY REMOVED FOLLOWING THE TINNING OPERATION.
- SCREW DESIGN PER MS16995, LENGTH + .188 ± .06
- DESIGN PER MS 16995. LGTH .812 ± .016

1 — INTERCONNECT ELECTRICAL COMPONENTS PER SCHEMATIC DIAGRAM 389D109.

- VENDORS ITEM, SEE SOURCE CONTROL DWG.
- TAG IDENT PART NO. & SERIAL NO PER P2S4517-1 SEE TABLE 1

- PRIOR TO INSTALLATION - ETCH TEFLON TUBING, ITEM 21, PER PS 586004.
- HOOK JOINT AND SOLDER
- USE EXCESS WIRE OF REF JUNCTION, ITEM 8.
- SECURE SPLICES TO REF JUNCTION WITH ITEM 18.
- HOOK JOINT TO BE POSITIONED APPROXIMATELY IN CENTER OF IT 2 AND CUT EXCESS THERMOCOUPLE LEAD

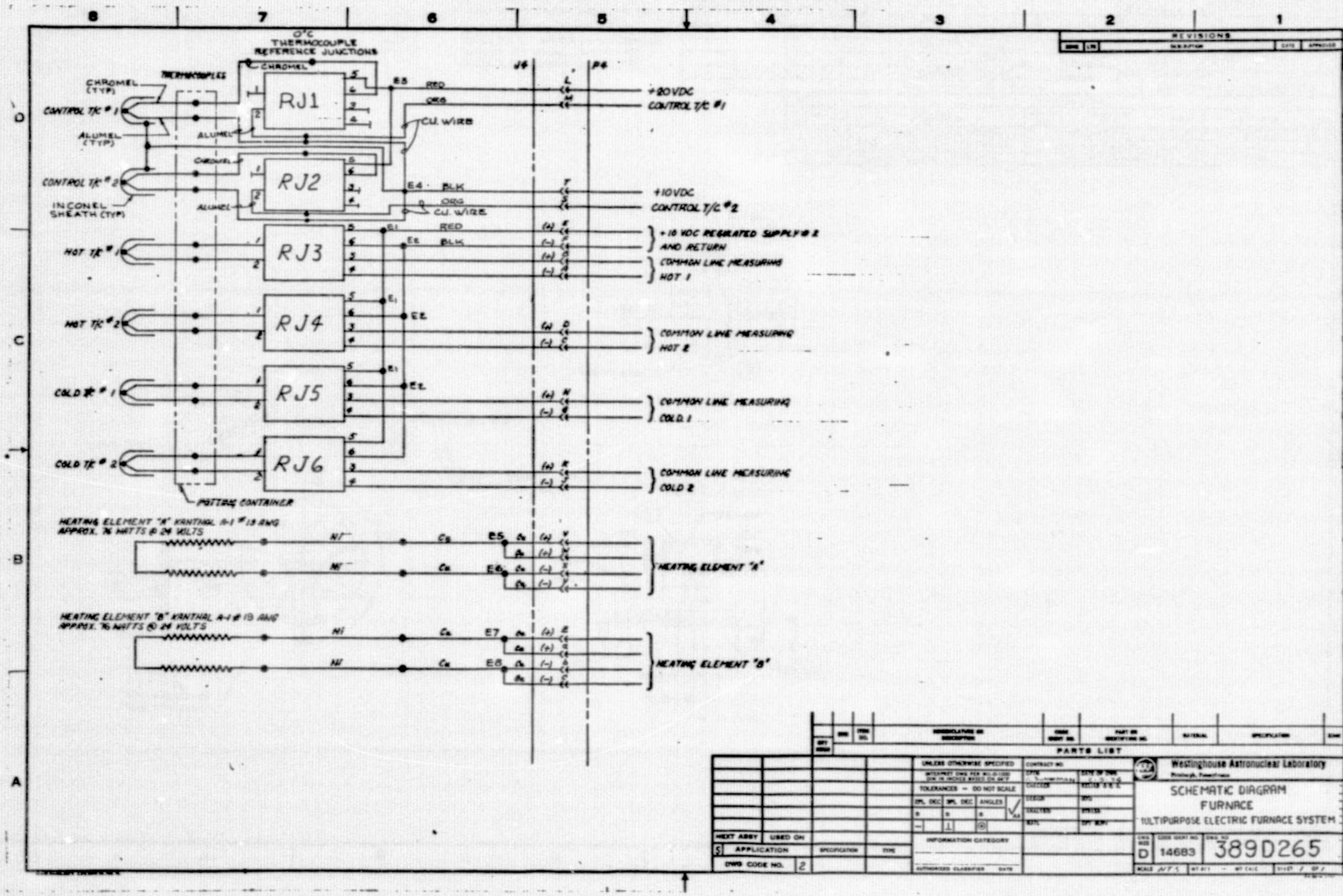
QTY	ITEM NO	NOMENCLATURE OR DESCRIPTION	PART OR IDENTIFYING NO.	SPECIFICATION
2	27	THERMOCOUPLE SHIELD	389D[illegible]	
4	26	THERMOCOUPLE SHIELD	389C[illegible]	
6	25	SLEEVE	383C[illegible]	
4	24	LOCKWASHER	[illegible]	
AR	23	SOLDER		[illegible]
REF	22	SCHEMATIC DIAGRAM	389D109	
AR	21	TUBING HEAT REACTIVE	[illegible]	[illegible]
2	20	THERMOCOUPLE	[illegible]	
AR	19	SOLDER		[illegible]
AR	18	EPOXY CASTING RESIN	[illegible]	[illegible]
6	17	NUT SELF LOCK [illegible]	[illegible]	
6	16	WASHER FLAT [illegible]	[illegible]	
6	15	[illegible]	[illegible]	
4	14	[illegible]	[illegible]	
6	13	NUT, SELF LOCK [illegible]	[illegible]	
4	11	SCREW CAP [illegible]	[illegible]	
4	10	SCREW CAP [illegible]	[illegible]	
4	9	STAND-OFF INSULATOR	[illegible]	[illegible]
6	8	THERMOCOUPLE ASSEMBLY [illegible]	[illegible]	
1	7	THERMOCOUPLE	[illegible]	
1	6	THERMOCOUPLE	[illegible]	
1	5	THERMOCOUPLE	[illegible]	
1	4	THERMOCOUPLE	[illegible]	
4	3	T/C POTTING CONTAINER FRONT	[illegible]	
4	2	T/C POTTING CONTAINER BACK	[illegible]	
1	1	[illegible] MOUNTING BRACKET	[illegible]	

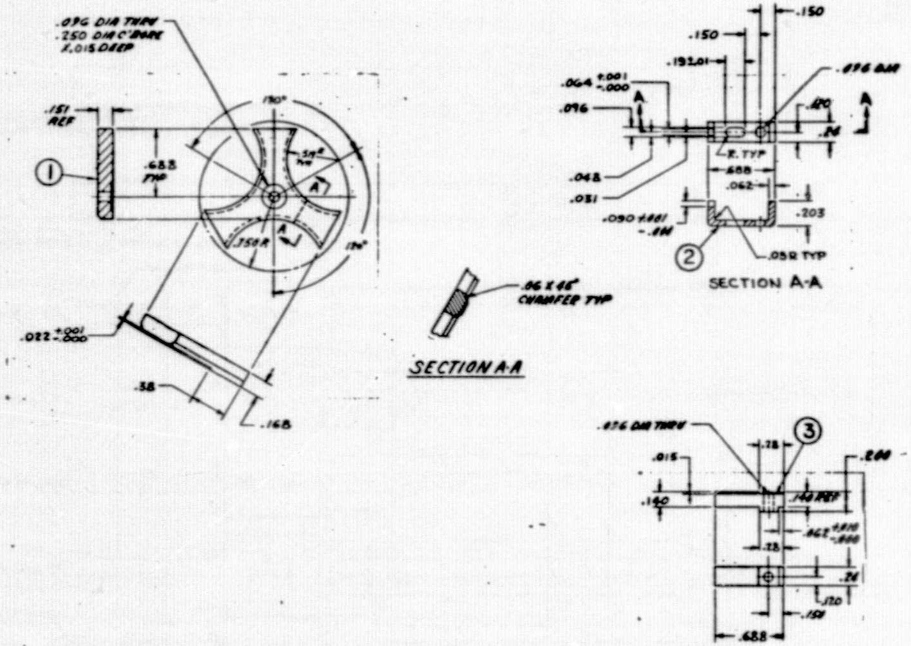
PARTS LIST

Westinghouse Astronuclear Laboratory

THERMOCOUPLE ASSY INSTRUMENT [illegible]

14083 1017[illegible]37


0°C THERMOCOUPLE REFERENCE JUNCTIONS
THERMOCOUPLES
CHROMEL
CHROMEL (TYP)
ALUMEL (TYP)
CONTROL T/C #1
CONTROL T/C #2
INCONEL SHEATH (TYP)
RJ1
RJ2
RJ3
RJ4
RJ5
RJ6
CU. WIRE
HOT T/C #1
HOT T/C #2
COLD T/C #1
COLD T/C #2
POTTING CONTAINER
J4
P4
RED
ORG
BLK
+20VDC
CONTROL T/C #1
+10VDC
CONTROL T/C #2
+10 VDC REGULATED SUPPLY #2 AND RETURN
COMMON LINE MEASURING HOT 1
COMMON LINE MEASURING HOT 2
COMMON LINE MEASURING COLD 1
COMMON LINE MEASURING COLD 2
HEATING ELEMENT "A" KANTHAL A-1 #13 AWG APPROX. 76 WATTS @ 24 VOLTS
HEATING ELEMENT "A"
HEATING ELEMENT "B" KANTHAL A-1 #13 AWG APPROX. 76 WATTS @ 24 VOLTS
HEATING ELEMENT "B"
REVISIONS
PARTS LIST
UNLESS OTHERWISE SPECIFIED
TOLERANCES — DO NOT SCALE
NEXT ASSY
USED ON
APPLICATION
DWG CODE NO. 2
INFORMATION CATEGORY
Westinghouse Astronuclear Laboratory
SCHEMATIC DIAGRAM
FURNACE
MULTIPURPOSE ELECTRIC FURNACE SYSTEM
D
14683
389D265



2. UNLESS OTHERWISE SPECIFIED REMOVE ALL BURRS & BREAK ALL SHARP EDGES .010 MAX R OR CHAMFER INTERNAL CORNERS .010 MAX R

1. MARK PART NO. & LOT SERIAL NO. ON CONTAINER PER P 294517-1, SEE IDENT COLUMN

QTY REQD		ITEM NO.	NOMENCLATURE OR DESCRIPTION	CODE IDENT NO.	PART OR IDENTIFYING NO.	MATERIAL	SPECIFICATION	
		3	THERMOCOUPLE CLAMP, CAP		389D263 H03 -	OFHC CU	QQ-C-576	
		2	THERMOCOUPLE CLAMP, BODY		389D263 H02 -	OFHC CU	QQ-C-502	
		1	THERMOCOUPLE CLAMP		389D263 H01 -	OFHC CU	QQ-C-502	

PARTS LIST

NEXT ASSY	USED ON		
		P2945171	IDENT
APPLICATION		SPECIFICATION	TYPE
DWG CODE NO.	2		

UNLESS OTHERWISE SPECIFIED
TOLERANCES — DO NOT SCALE

INFORMATION CATEGORY
N.A.
AUTHORIZED CLASSIFIER DATE

Westinghouse Astronuclear Laboratory
Pittsburgh, Pennsylvania

THERMOCOUPLE CLAMPS
INSTRUMENT CHAMBER
MULTIPURPOSE ELECTRIC FURNACE SYSTEM

DWG SIZE D | CODE IDENT NO 14683 | DWG NO 389D263

SCALE 1 | SHEET 1 OF 1

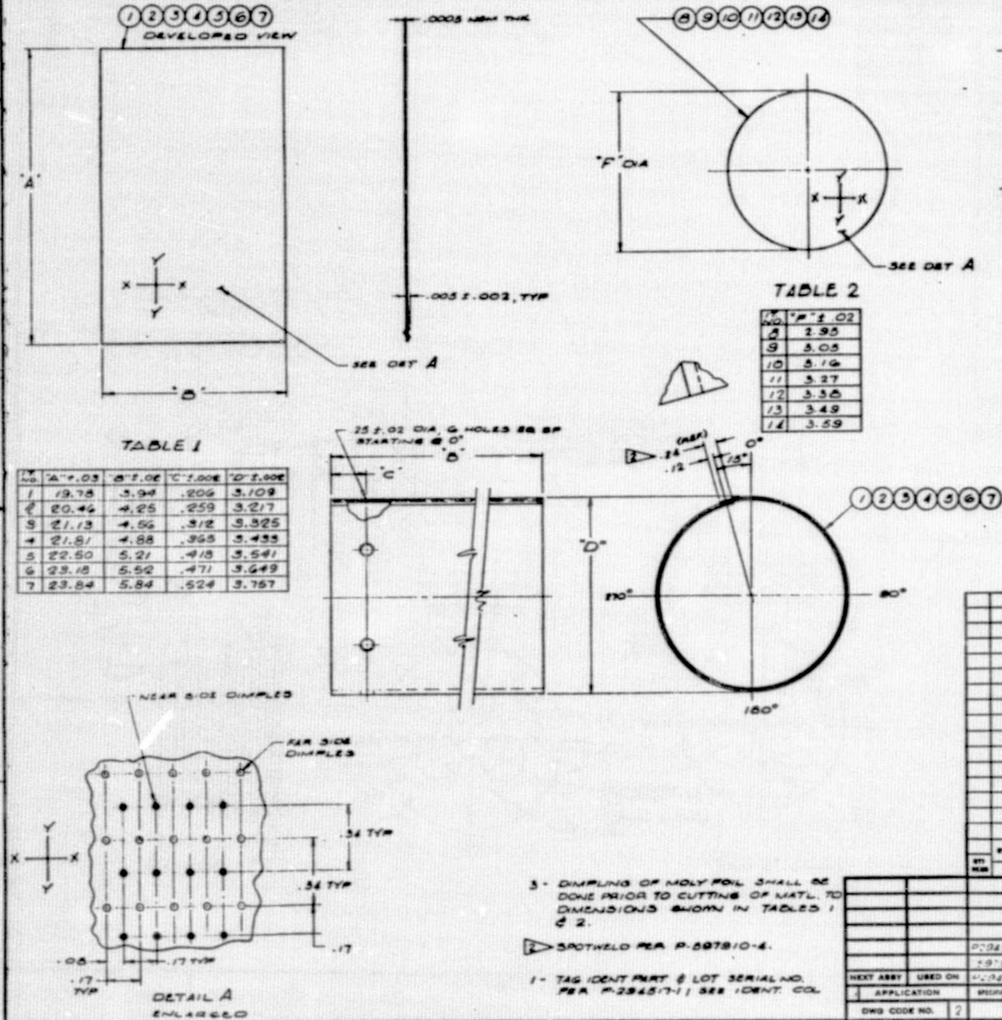


TABLE 1

IT NO.	"A" ±.03	"B" ±.02	"C" ±.002	"D" ±.002
1	19.78	3.94	.206	3.109
2	20.46	4.25	.259	3.217
3	21.13	4.56	.312	3.325
4	21.81	4.88	.365	3.433
5	22.50	5.21	.418	3.541
6	23.18	5.52	.471	3.649
7	23.84	5.84	.524	3.757

TABLE 2

IT NO.	"F" ±.02
8	2.95
9	3.05
10	3.16
11	3.27
12	3.38
13	3.49
14	3.59

3 - DIMPLING OF MOLY FOIL SHALL BE DONE PRIOR TO CUTTING OF MATL. TO DIMENSIONS SHOWN IN TABLES 1 & 2.

2 SPOTWELD PER P-597910-4.

1 - TAG IDENT PART & LOT SERIAL NO. PER P-294517-1 | SEE IDENT. COL

QTY	ITEM NO.	NOMENCLATURE OR DESCRIPTION	CODE IDENT NO	PART OR IDENTIFYING NO	MATERIAL	SPECIFICATION	ZONE
	14	DISC, HEAT SHIELD (FOIL)		389D187H14	MO	AMS 7800	
	13			H13			
	12			H12			
	11			H11			
	10			H10			
	9			H09			
	8	DISC, HEAT SHIELD (FOIL)		H08			
	7	HEAT SHIELD (FOIL)		H07			
	6			H06			
	5			H05			
	4			H04			
	3			H03			
	2			H02			
	1	HEAT SHIELD (FOIL)		389D187H01			

PARTS LIST

P294520-1 CLEAN
597910-4 WELD
P294517-1 IDENT

NEXT ASSY | USED ON
APPLICATION | SPECIFICATION | TYPE
DWG CODE NO. 2

UNLESS OTHERWISE SPECIFIED
TOLERANCES - DO NOT SCALE
2PL DEC | 3PL DEC | ANGLES

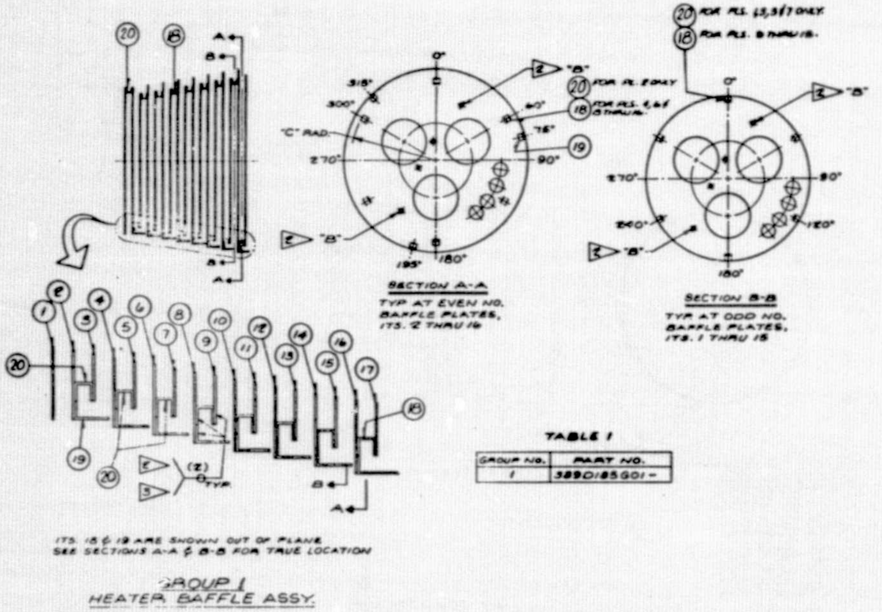
INFORMATION CATEGORY
N-A
AUTHORIZED CLASSIFIER | DATE

CONTRACT NO
DFTR | DATE OF ENG.
CHECKER | RELEASE
DESIGN | MFG
ANALYSIS | STRESS
APPD | DPT SUPV

Westinghouse Astronuclear Laboratory

HEAT SHIELDS (FOIL)
FURNACE CHAMBER
ULTRAPURE ELECTRON BEAM SYSTEM

DWG SIZE D | CODE IDENT NO 14683 | DWG NO 389D187



ITEM	"C" RAD.
1	
2	1.38
3	
4	1.43
5	
6	1.48
7	
8	1.54
9	
10	1.59
11	
12	1.64
13	
14	1.70
15	
16	1.75
17	

TABLE 1

GROUP NO.	PART NO.
1	389D185G01-

QTY REQD	SYM	ITEM NO	NOMENCLATURE OR DESCRIPTION	CODE IDENT NO	PART OR IDENTIFYING NO	MATERIAL	SPECIFICATION
15		20	BAFFLE TAB		800C882H04-		
18		19	BAFFLE TAB		800C882H02-		
33		18	BAFFLE TAB		800C882H01-		
1		17	BAFFLE PLATE		577F647H017-		
1		16	BAFFLE PLATE		577F647H016-		
1		15	BAFFLE PLATE		577F647H015-		
1		14	BAFFLE PLATE		577F647H014-		
1		13	BAFFLE PLATE		577F647H013-		
1		12	BAFFLE PLATE		577F647H012-		
1		11	BAFFLE PLATE		577F647H011-		
1		10	BAFFLE PLATE		577F647H010-		
1		9	BAFFLE PLATE		577F647H09-		
1		8	BAFFLE PLATE		577F647H08-		
1		7	BAFFLE PLATE		577F647H07-		
1		6	BAFFLE PLATE		577F647H06		
1		5	BAFFLE PLATE		577F647H05-		
1		4	BAFFLE PLATE		577F647H04-		
1		3	BAFFLE PLATE		577F647H03-		
1		2	BAFFLE PLATE		577F647H02-		
1		1	BAFFLE PLATE		577F647H01-		

PARTS LIST

3 SPOTWELD PER P597910-4

2 ALL HOLES IN BAFFLE PLATES MUST BE IN LINE WITH EACH OTHER PER ORIENTATION SHOWN SO THAT A .128 $^{+.000}_{-.001}$ DIA. ROD WILL PASS FREELY THRU 2 HOLES MARKED "B".

1-TAG IDENT PART NO. & SERIAL NO. PER PE94517-1, SEE TABLE 1

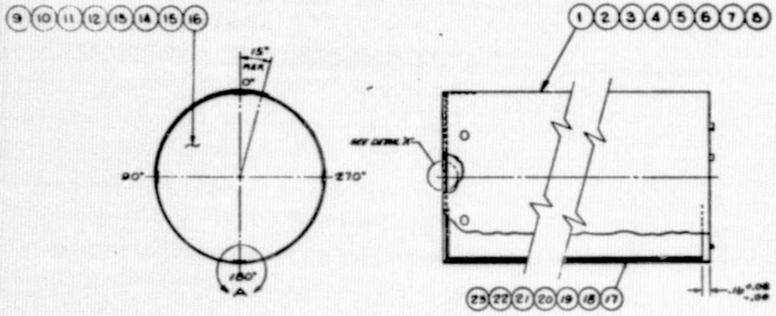
		PE94520-1	CLEANING
		P597910-4	WELDING
NEXT ASSY	USED ON	PE94517-1	IDENT
APPLICATION		SPECIFICATION	TYPE
DWG CODE NO.	2		

UNLESS OTHERWISE SPECIFIED
TOLERANCES — DO NOT SCALE
CONTRACT NO
INFORMATION CATEGORY
N A
AUTHORIZED CLASSIFIER DATE

Westinghouse Astronuclear Laboratory

HEATER BAFFLE ASSY.
FURNACE CHAMBER
MULTIPURPOSE ELECTRIC HEATER SYSTEM

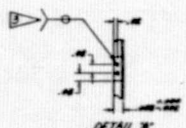
D 14683 389D185



GROUPS 1,2,3,4,5,6,7 & 8
HEAT SHIELD ASSYS.

TABLE I

GROUP NO.	PART NO.
1	389D184G01-
2	389D184G02-
3	389D184G03-
4	389D184G04-
5	389D184G05-
6	389D184G06-
7	38[illegible]D184G07-
8	389[illegible]184G08-



DETAIL "A"
TYP 4 PLACES

G08	G07	G06	G05	G04	G03	G02	G01	ITEM NO.	NOMENCLATURE OR DESCRIPTION	CODE IDENT NO.	PART OR IDENTIFYING NO.	MATERIAL	SPECIFICATION
1								23	HEAT SHIELDS (FOIL)		389D187H07		
	1							22			389D187H06		
		1						21			389D187H05		
			1					20			389D187H04		
				1				19			389D187H03		
					1			18			389D187H02		
						1		17	HEAT SHIELDS (FOIL)		389D187H01		
1								16	HEAT SHIELD		800C884H08-		
	1							15			800C884H07-		
		1						14			800C[illegible]H06-		
			1					13			800C[illegible]H05-		
				1				12			[illegible]H04-		
					1			11			[illegible]H03-		
						1		10			[illegible]884H02-		
							1	9	HEAT SHIELD		[illegible]884H01-		
1								8	CYLINDER, HEAT SHIELD		[illegible]185H08-		
	1							7			[illegible]		
		1						6			[illegible]		
			1					5			[illegible]		
				1				4			[illegible]185H04-		
					1			3			[illegible]185H03-		
						1		2			[illegible]185H02-		
							1	1	CYLINDER, HEAT SHIELD		[illegible]H01-		

QTY REQD — PARTS LIST

3 SPOTWELD PER PS97910-4

2 UNPLATED SIDE OF HEAT SHIELD TO BE MATED WITH CYLINDER HEAT SHIELD.

1 TAG IDENT PART NO. & SERIAL NO. PER P 294517-1. SEE TABLE-1

NEXT ASSY	USED ON	SPECIFICATION	TYPE
		PS97910-4	WELDING
		P294517-1	IDENT
APPLICATION			
DWG CODE NO.			

UNLESS OTHERWISE SPECIFIED
TOLERANCES — DO NOT SCALE
2PL DEC | 3PL DEC | ANGLES

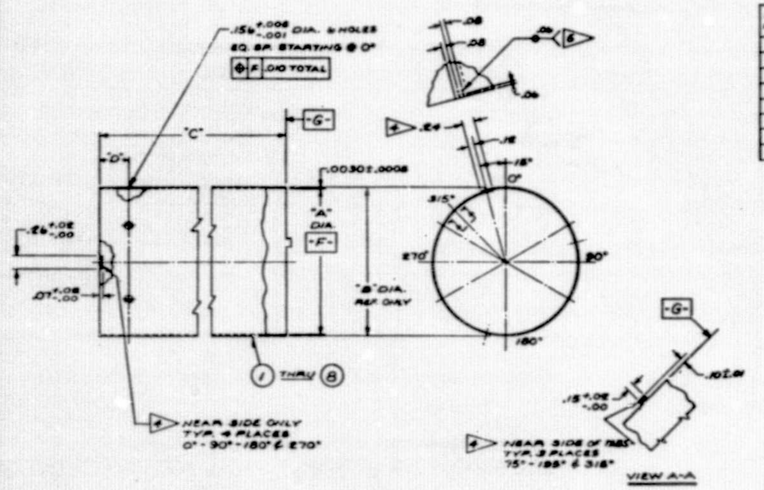
INFORMATION CATEGORY
N-A
AUTHORIZED CLASSIFIER DATE

CONTRACT NO

Westinghouse Astronuclear Laboratory

CYLINDER HEAT SHIELD ASSY
FURNACE CHAMBER
MULTIPURPOSE ELECTRIC FURNACE SYSTEM

DWG SIZE D | CODE IDENT NO 14683 | DWG NO. 389D184



IT. NO	"A" +.006 -.000 DIA.	"B" +.006 -.000 REF. DIA.	"C" +.000 -.010 LG.	"D" +.000 -.002
1	3.006	3.012	3.860	.226
2	3.114	3.120	4.177	.279
3	3.222	3.228	4.494	.332
4	3.330	3.336	4.811	.385
5	3.438	3.444	5.128	.438
6	3.546	3.552	5.445	.491
7	3.654	3.660	5.762	.544
8	3.762	3.768	6.079	.597

6- DIMS. & TOL. APPLY WHEN PARTS ARE RESTRAINED ON A MANDREL.

5 SPOTWELD PER P597910-4.

4 REMOVE GOLD PLATING FROM MATING SURFACES TO BE SPOTWELDED AND FROM SURFACE AREA INDICATED PER P597993 ON ITS. 5, 6, 7 & 8 ONLY.

3- REMOVE ALL BURRS & BREAK ALL SHARP EDGES .010 MAX. R OR CHAMFER INTERNAL CORNERS .010 MAX. R.

2- HEAT SHIELDS, ITS. 5, 6, 7 & 8 ONLY SHALL BE GOLD PLATED TO .0002±.0001 THICK PER P597993 & POLISHED TO A BRIGHT METALLIC FINISH, PRIOR TO FORMING & WELDING.

1- TAG IDENT PART NO. & SERIAL NO. PER P294517-1, SEE IDENT COLUMN.

QTY REQD		ITEM NO	NOMENCLATURE OR DESCRIPTION	CODE IDENT NO	PART OR IDENTIFYING NO.	MATERIAL	SPECIFICATION
		8	CYLINDER, HEAT SHIELD		389D183H08-	Mo	AMS 7800
		7	CYLINDER, HEAT SHIELD		389D183H07-	Mo	AMS 7800
		6	CYLINDER, HEAT SHIELD		389D183H06-	Mo	AMS 7800
		5	CYLINDER, HEAT SHIELD		389D183H05-	Mo	AMS 7800
		4	CYLINDER, HEAT SHIELD		389D183H04-	Mo	AMS 7800
		3	CYLINDER, HEAT SHIELD		389D183H03-	Mo	AMS 7800
		2	CYLINDER, HEAT SHIELD		389D183H02-	Mo	AMS 7800
		1	CYLINDER, HEAT SHIELD		389D183H01-	Mo	AMS 7800

PARTS LIST

SPECIFICATION	TYPE
P294520-1	CLEAN
P597910-4	WELDING
P597993	PLATING
P294517-1	IDENT

NEXT ASSY | USED ON | APPLICATION

DWG CODE NO. 2

UNLESS OTHERWISE SPECIFIED

TOLERANCES — DO NOT SCALE

2PL DEC ±.02 | 3PL DEC ±.005 | ANGLES

INFORMATION CATEGORY N.A.

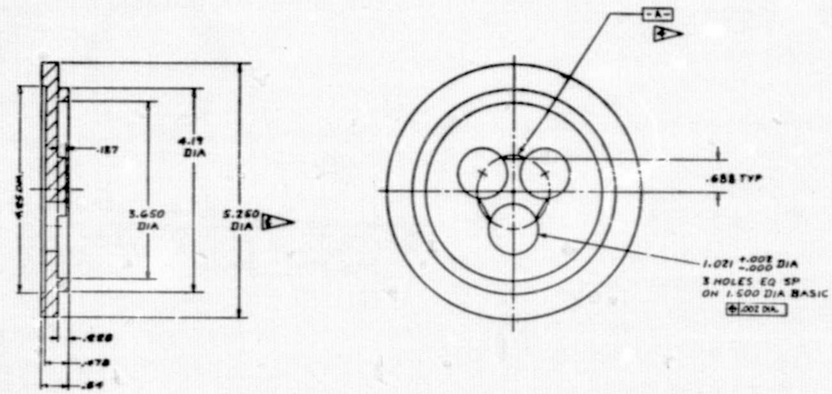
AUTHORIZED CLASSIFIER DATE

CONTRACT NO

Westinghouse Astronuclear Laboratory

CYLINDER, HEAT SHIELD
FURNACE CHAMBER
MULTIPURPOSE ELECTRIC FURNACE SYSTEM

SIZE D | CODE IDENT NO 14683 | DWG NO 389D183



4 THIS IS AN INTERFACE CONTROL DIMENSION & CANNOT BE CHANGED WITHOUT PRIOR APPROVAL OF PROGRAM MANAGER.

4 DATUM -A- IS THE COMMON AXIS CREATED BY THE 3 1.021 DIA HOLES.

3 - UNLESS OTHERWISE SPECIFIED, FEATURES SHOWN COAXIAL TO DATUM -A- ARE A .006 DIA

2 - TAG IDENT PART NO. & SERIAL NO. PER P-294517-1. SEE IDENT COLUMN.

1 - UNLESS OTHERWISE SPECIFIED, REMOVE ALL BURRS & BREAK ALL SHARP EDGES .010 MAX RADIUS OR CHAMFER. INTERNAL CORNERS .010 MAX R.

QTY REQD	ITEM NO.	NOMENCLATURE OR DESCRIPTION	CODE IDENT NO.	PART OR IDENTIFYING NO.	MATERIAL	SPECIFICATION
	1	HEAT TRANSFER FLANGE		389D182H01	OFHC - CU	

PARTS LIST

NEXT ASSY	USED ON	P294517-1	IDENT
APPLICATION		SPECIFICATION	TYPE
DWG CODE NO.			

UNLESS OTHERWISE SPECIFIED
TOLERANCES — DO NOT SCALE

2PL DEC	3PL DEC	ANGLES
±.02	±.005	

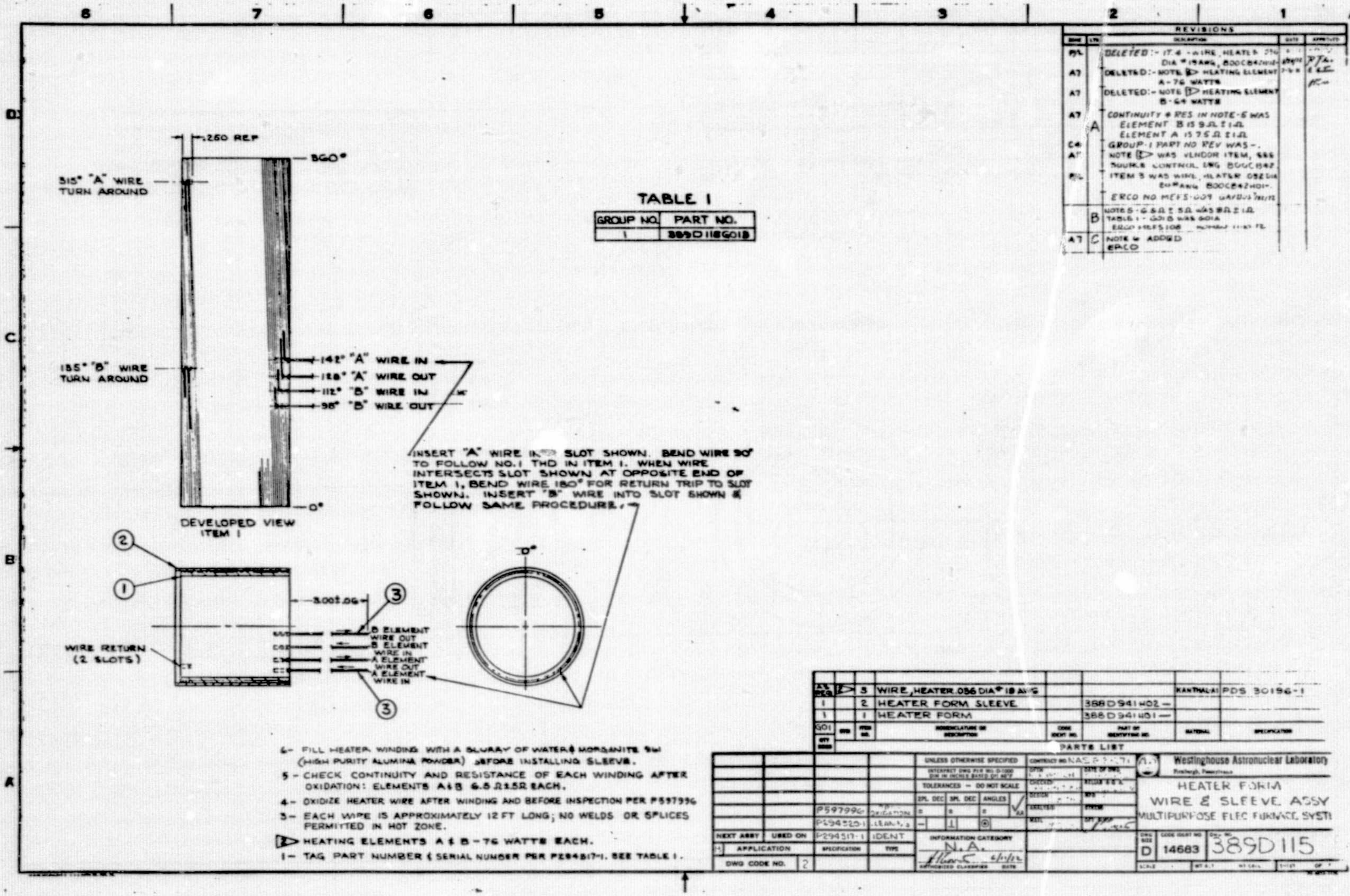
INFORMATION CATEGORY
N-A
AUTHORIZED CLASSIFIER DATE

CONTRACT NO.
DFTR | DATE OF DWG
CHECKER | RELEASE
DESIGN | MFG
ANALYSIS | STRESS
MATL | OPT ENG

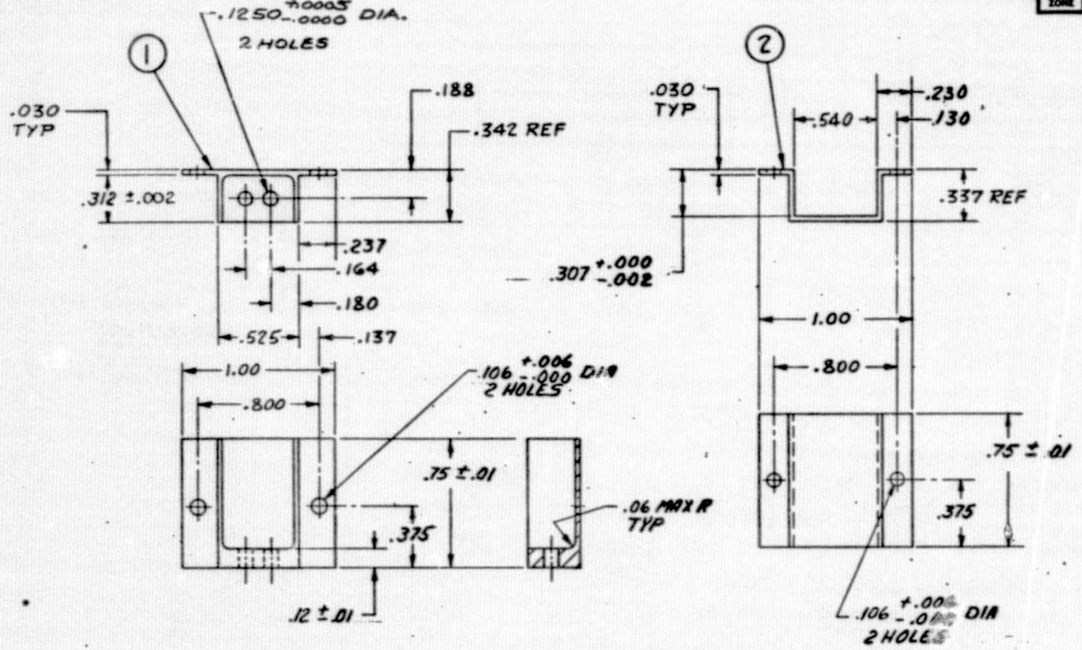
Westinghouse Astronuclear Laboratory

HEAT TRANSFER FLANGE
FURNACE CHAMBER
MULTIPURPOSE ELECTRIC FURNACE SYSTEM

DWG SIZE	CODE IDENT NO.	DWG NO.
D	14683	389D182



.250 REF
360°
315° "A" WIRE TURN AROUND
135° "B" WIRE TURN AROUND
142° "A" WIRE IN
128° "A" WIRE OUT
112° "B" WIRE IN
98° "B" WIRE OUT
0°
DEVELOPED VIEW ITEM 1
TABLE I
GROUP NO. | PART NO.
1 | 389D115G01
INSERT "A" WIRE INTO SLOT SHOWN. BEND WIRE 90° TO FOLLOW NO. 1 THD IN ITEM 1. WHEN WIRE INTERSECTS SLOT SHOWN AT OPPOSITE END OF ITEM 1, BEND WIRE 180° FOR RETURN TRIP TO SLOT SHOWN. INSERT "B" WIRE INTO SLOT SHOWN & FOLLOW SAME PROCEDURE.
3.00±.06
B ELEMENT WIRE OUT
B ELEMENT WIRE IN
A ELEMENT WIRE OUT
A ELEMENT WIRE IN
WIRE RETURN (2 SLOTS)
0°
REVISIONS
A
B
C
WIRE, HEATER .036 DIA 19 AWG
HEATER FORM SLEEVE
HEATER FORM
388D941H02
388D941H01
KANTHAL A1
PDS 30196-1
PARTS LIST
P597996
P294525-1
P294517-1
IDENT
N.A.
Westinghouse Astronuclear Laboratory
HEATER FORM
WIRE & SLEEVE ASSY
MULTIPURPOSE ELEC FURNACE SYST
D
14683
389D115
6- FILL HEATER WINDING WITH A SLURRY OF WATER & MORGANITE 941 (HIGH PURITY ALUMINA POWDER) BEFORE INSTALLING SLEEVE.
5- CHECK CONTINUITY AND RESISTANCE OF EACH WINDING AFTER OXIDATION: ELEMENTS A & B 6.5 Ω ±.5 Ω EACH.
4- OXIDIZE HEATER WIRE AFTER WINDING AND BEFORE INSPECTION PER P597996
3- EACH WIRE IS APPROXIMATELY 12 FT LONG; NO WELDS OR SPLICES PERMITTED IN HOT ZONE.
2- HEATING ELEMENTS A & B - 76 WATTS EACH.
1- TAG PART NUMBER & SERIAL NUMBER PER P294517-1. SEE TABLE I.



800C886

QTY REQD	SYM	ITEM NO.	NOMENCLATURE OR DESCRIPTION	CODE IDENT NO.	PART OR IDENTIFYING NO.	MATERIAL	SPECIFICATION	ZONE
		2	T/C POTTING CONTAINER - FRONT		800C886H02-	CRES	AMS 5639	
		1	T/C POTTING CONTAINER - BACK		800C886H01-	CRES	AMS 5639	

PARTS LIST

2-TAG IDENT PART NO. & SERIAL NO. PER P294517-1 SEE IDENT COLUMN.

1-UNLESS OTHERWISE SPECIFIED, REMOVE ALL BURRS & BREAK ALL SHARP EDGES .010 MAX RADIUS OR CHAMFER. INTERNAL CORNERS .010 MAX R.

NEXT ASSY	USED ON	P294517-1	IDENT
G	APPLICATION	SPECIFICATION	TYPE
DWG CODE NO.	2		

UNLESS OTHERWISE SPECIFIED
INTERPRET DWG PER MIL-D-1000
DIM IN INCHES BASED ON 68°F

TOLERANCES — DO NOT SCALE

2PL DEC	3PL DEC	ANGLES	125 √ AA
±.02	±.005	±0°30'	

INFORMATION CATEGORY
N-A
AUTHORIZED CLASSIFIER DATE

CONTRACT NO.	
DFTM	DATE OF DWG 9-25-73
CHECKER	RELIAB & Q. A.
DESIGN	MFG
ANALYSIS	STRESS
MATL	DFT SUPV

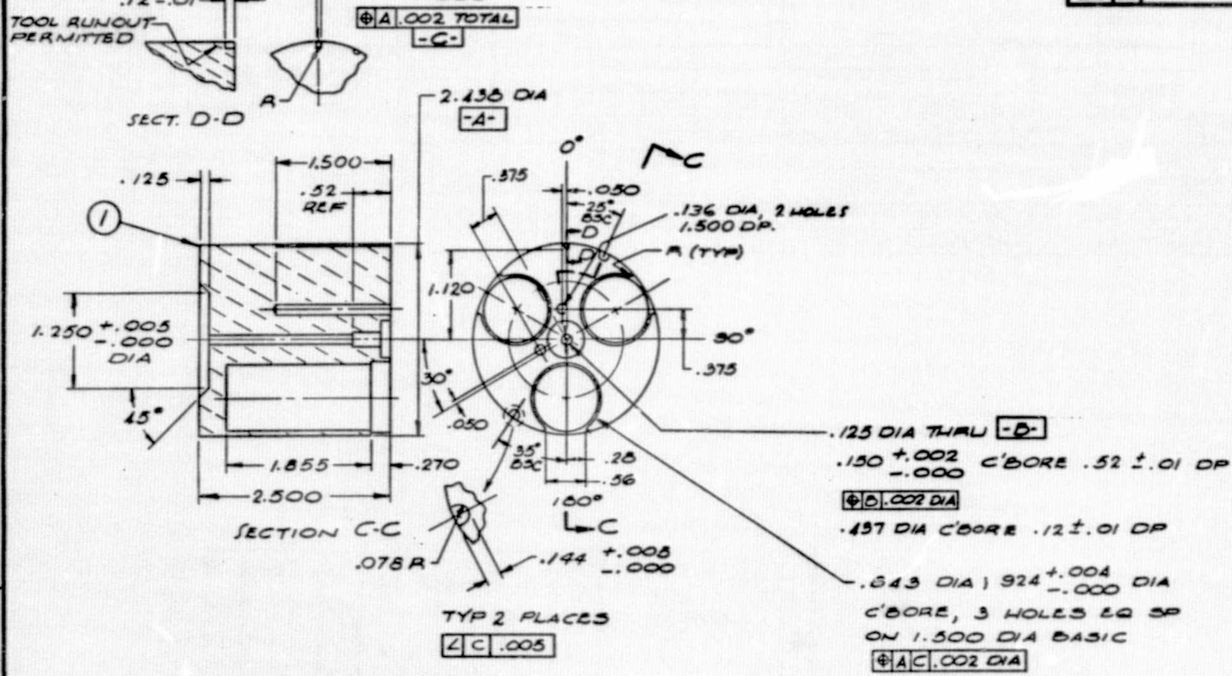
Westinghouse Astronuclear Laboratory
Pittsburgh, Pennsylvania

T/C POTTING CONTAINER
INSTRUMENT CHAMBER
MULTIPURPOSE ELECTRIC FURNACE SYSTEM

DWG SIZE	CODE IDENT NO.	DWG NO.
C	14683	800C886

SCALE 2/1 | WT ACT. | WT CALC | SHEET 1 OF 1

REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROVED



4. UNLESS OTHERWISE SPECIFIED, FEATURES SHOWN COAXIAL TO DATUM -A- ARE ⊕ A .006 DIA

3 ▷ GRAPHITE; FURNISHED BY ULTRA CARBON CORP, BAY CITY, MICH.

2. TAG IDENT PART NO. & SERIAL NO. PER P294517-1. SEE IDENT. COL.

1. UNLESS OTHERWISE SPECIFIED, REMOVE ALL BURRS AND BREAK ALL SHARP EDGES .010 MAX RADIUS OR CHAMFER. INTERNAL CORNERS .010 MAX R.

QTY REQD	SYM	ITEM NO.	NOMENCLATURE OR DESCRIPTION	CODE IDENT NO.	PART OR IDENTIFYING NO.	MATERIAL	SPECIFICATION	ZONE
		1	HEAT LEVELER		800C885H01 -	3 ▷	PDS 30265	

PARTS LIST

UNLESS OTHERWISE SPECIFIED	INTERPRET DWG PER MIL-D-1000; DIM IN INCHES BASED ON 68°F
TOLERANCES — DO NOT SCALE	2PL. DEC ±.02; 3PL. DEC ±.005; ANGLES ±0°30'; 125 √ AA
CONTRACT NO.	
DFTM R. BAKER	DATE OF DWG 8-16-73
CHECKER D. RENNIE 8/16/73	RELIAB & Q. A.
DESIGN	MFG
ANALYSIS	STRESS
MATL	GFT SUPV
NEXT ASSY: P294517-1	USED ON: IDENT
APPLICATION	SPECIFICATION / TYPE
DWG CODE NO. 2	
INFORMATION CATEGORY N-A	AUTHORIZED CLASSIFIER / DATE

Westinghouse Astronuclear Laboratory
Pittsburgh, Pennsylvania

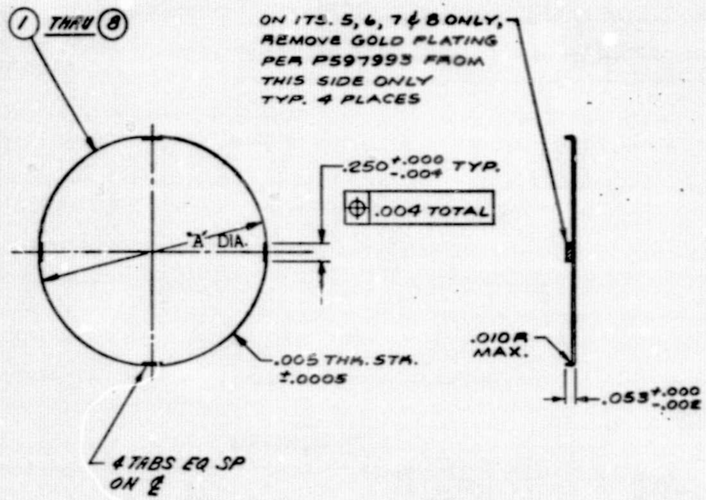
HEAT LEVELER
FURNACE CHAMBER
MULTIPURPOSE ELECTRIC FURNACE SYSTEM

DWG SIZE	CODE IDENT NO.	DWG NO.
C	14683	800C885

SCALE 1:1 | WT ACT. | WT CALC | SHEET 1 OF 1

800C885

						REVISIONS		
ZONE	LTR	DESCRIPTION	DATE	APPROVED				



IT.	"A" +.000 -.003 DIA
1	2.996
2	3.104
3	3.212
4	3.320
5	3.428
6	3.536
7	3.644
8	3.752

QTY REQD	SYM	ITEM NO.	NOMENCLATURE OR DESCRIPTION	CODE IDENT NO.	PART OR IDENTIFYING NO.	MATERIAL	SPECIFICATION	ZONE
		8	HEAT SHIELD		800C884H08-	Mo	AMS 7800	
		7	HEAT SHIELD		800C884H07-	Mo	AMS 7800	
		6	HEAT SHIELD		800C884H06-	Mo	AMS 7800	
		5	HEAT SHIELD		800C884H05-	Mo	AMS 7800	
		4	HEAT SHIELD		800C884H04-	Mo	AMS 7800	
		3	HEAT SHIELD		800C884H03-	Mo	AMS 7800	
		2	HEAT SHIELD		800C884H02-	Mo	AMS 7800	
		1	HEAT SHIELD		800C884H01-	Mo	AMS 7800	

PARTS LIST

3- REMOVE ALL BURRS & BREAK ALL SHARP EDGES .010 MAX R OR CHAM. INT. CORNERS .010 MAX R

2- HEAT SHIELDS, ITS. 5, 6, 7 & 8 SHALL BE GOLD PLATED TO .0002±.0001 THICKNESS PER P597993 AND POLISHED TO A BRIGHT METALLIC FINISH.

1. TAG IDENT PART NO. & SERIAL NO. PER P294517-1. SEE IDENT COLUMN

		P597993	PLATING
NEXT ASSY	USED ON	P294517-1	IDENT
APPLICATION		SPECIFICATION	TYPE
DWG CODE NO.	2		

UNLESS OTHERWISE SPECIFIED
INTERPRET DWG PER MIL-D-1000
DIM IN INCHES BASED ON 68°F
TOLERANCES — DO NOT SCALE
2PL DEC ± | 3PL DEC ± | ANGLES ± | 125 AA

INFORMATION CATEGORY: N-A
AUTHORIZED CLASSIFIER DATE

CONTRACT NO.	
DFTM H.K.	DATE OF DWG 8-6-73
CHECKER O'Keefe 8/7/73	RELIAB & Q. A.
DESIGN	M/G
ANALYSIS	STRESS
MATL	DFT SUPV

Westinghouse Astronuclear Laboratory
Pittsburgh, Pennsylvania

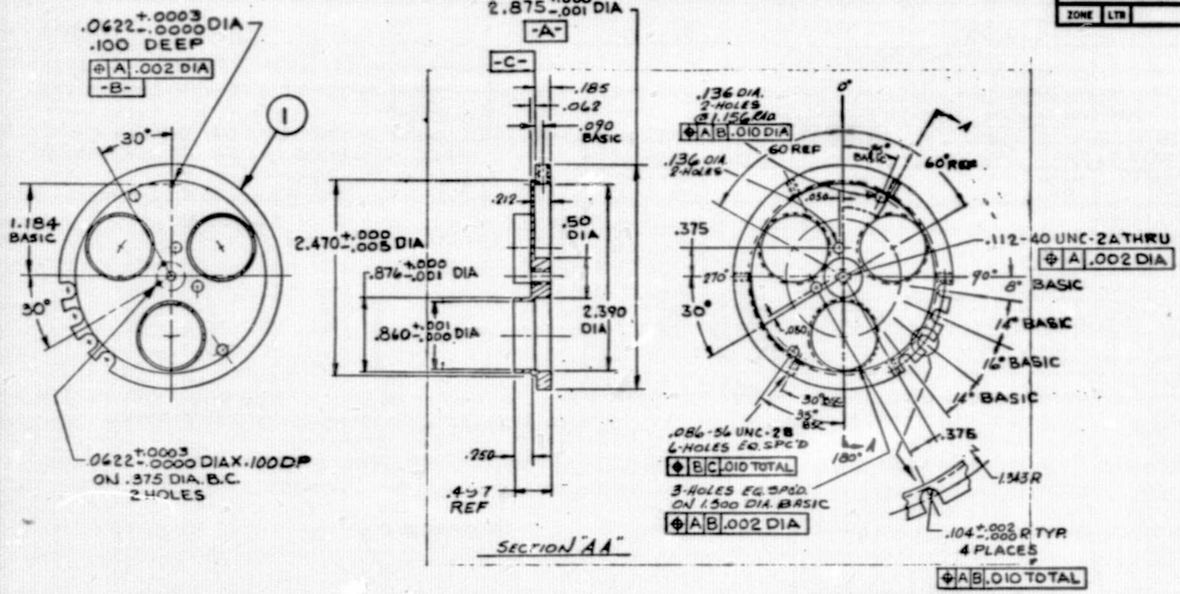
HEAT SHIELD
FURNACE CHAMBER
MULTIPURPOSE ELECTRIC FURNACE SYSTEM

DWG SIZE	CODE IDENT NO.	DWG NO.
C	14683	800C884

SCALE NTS | WT ACT. | WT CALC | SHEET 1 OF 1

800C884

REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROVED



800C883

3 - UNLESS OTHERWISE SPECIFIED FEATURES SHOWN COAXIAL TO DATUM -A- ARE ⌖ A .006 DIA

2 - TAG IDENT PART NO. & SERIAL NO. PER P294517-1, SEE IDENT COLUMN.

1 - UNLESS OTHERWISE SPECIFIED REMOVE ALL BURRS & BREAK ALL SHARP EDGES .010 MAX RADIUS OR CHAMFER. INTERNAL CORNERS .010 MAX R.

QTY REQD	SYM	ITEM NO.	NOMENCLATURE OR DESCRIPTION	CODE IDENT NO.	PART OR IDENTIFYING NO.	MATERIAL	SPECIFICATION	ZONE
		1	HEATER HOUSING BOTTOM FLANGE		800C883H01-	200Ni	ASTM B-160-61	

PARTS LIST

NEXT ASSY	USED ON	P-294517-1	IDENT
APPLICATION		SPECIFICATION	TYPE
DWG CODE NO.	2		

UNLESS OTHERWISE SPECIFIED
INTERPRET DWG PER MIL-D-1000
DIM IN INCHES BASED ON 68°F
TOLERANCES — DO NOT SCALE

2PL DEC	3PL DEC	ANGLES
±.02	±.005	±0°30'

INFORMATION CATEGORY: N.A.
AUTHORIZED CLASSIFIER — DATE

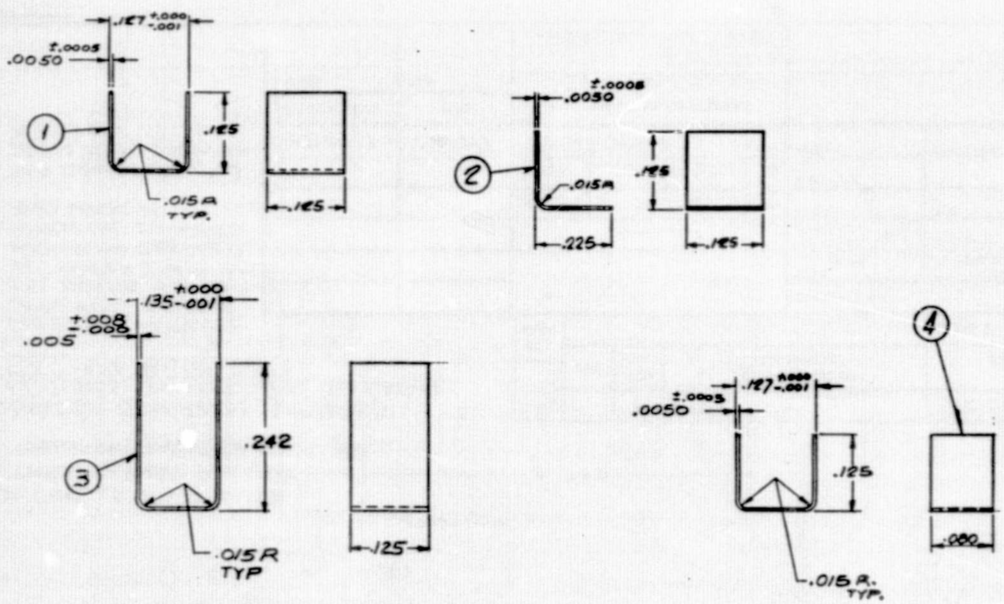
CONTRACT NO.
DFTM: H. Kozlowski — DATE OF DWG: 8-6-73
CHECKER: D. Rawlie — RELIAB & Q.A.
DESIGN — MFG
ANALYSIS — STRESS
MATL — DIV SUPV

Westinghouse Astronuclear Laboratory
Pittsburgh, Pennsylvania

HEATER HOUSING BOTTOM FLANGE
FURNACE CHAMBER
MULTIPURPOSE ELECTRIC FURNACE SYSTEM

DWG SIZE	CODE IDENT NO.	DWG NO.
C	14683	800C883

SCALE — WT ACT — WT CALC — SHEET



800C882

QTY REQD	SYM	ITEM NO.	NOMENCLATURE OR DESCRIPTION	CODE IDENT NO.	PART OR IDENTIFYING NO.	MATERIAL	SPECIFICATION	ZONE
		4	BAFFLE TAB		800C882H04-	Mo	AMS 7800	
		3	BAFFLE TAB		800C882H03-	Mo	AMS 7800	
		2	BAFFLE TAB		800C882H02-	Mo	AMS 7800	
		1	BAFFLE TAB		800C882H01-	Mo	AMS 7800	

PARTS LIST

2- UNLESS OTHERWISE SPECIFIED, REMOVE ALL BURRS & BREAK ALL SHARP EDGES .002 MAX. RADIUS OR CHAMFER.

1- MARK PART NO. & LOT SERIAL NO. ON CONTAINER PER P294517-1 SEE IDENT. COLUMN

NEXT ASSY	USED ON
P294517-1	IDENT
G APPLICATION	SPECIFICATION / TYPE
DWG CODE NO.	2

UNLESS OTHERWISE SPECIFIED
INTERPRET DWG PER MIL-D-1000
DIM IN INCHES BASED ON 68°F
TOLERANCES — DO NOT SCALE

2PL DEC	3PL DEC	ANGLES	
±.02	±.005	±0°30'	125 √ AA

INFORMATION CATEGORY
N-A
AUTHORIZED CLASSIFIER DATE

CONTRACT NO.	
DFTM H. KOZLOWSKI	DATE OF DWG 8-7-73
CHECKER D. Kendle 8/7/73	RELIAB & Q. A.
DESIGN	MFG
ANALYSIS	STRESS
MATL	DPT SUPV

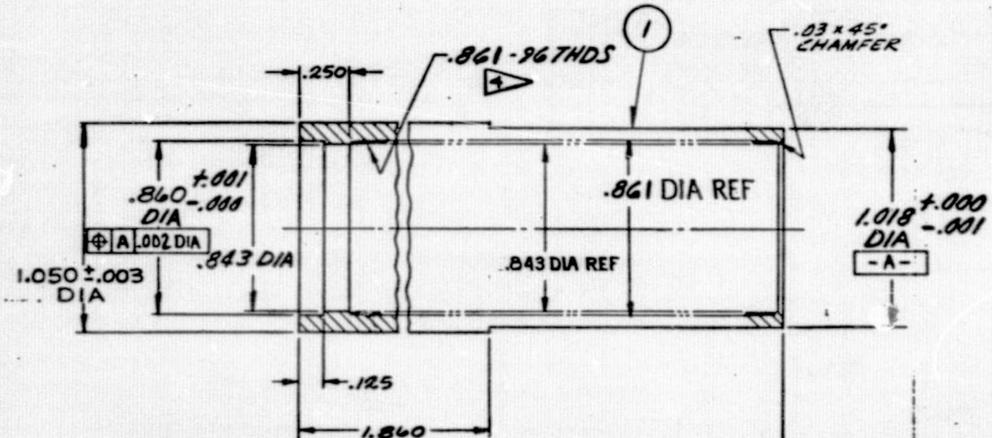
Westinghouse Astronuclear Laboratory
Pittsburgh, Pennsylvania

HEATER BAFFLE TAB
FURNACE CHAMBER
MULTIPURPOSE ELECTRIC FURNACE SYSTEM

DWG SIZE	CODE IDENT NO.	DWG NO.
C	14683	800C882

SCALE 8/1 WT ACT. WT CALC SHEET 1 OF 1

REVISIONS				
SYM	ZONE	DESCRIPTION	DATE	APPROVED



4. THIS IS NOT A MATING THREAD-REQ'D FOR HEAT TRANSFER CHARACTERISTICS ONLY.

3. UNLESS OTHERWISE SPECIFIED FEATURES SHOWN COAXIAL TO DATUM -A- ARE ⊕ A .006 DIA.

2. UNLESS OTHERWISE SPECIFIED, REMOVE ALL BURRS, & BREAK ALL SHARP EDGES .010 MAX. R OR CHAMFER. INTERNAL CORNERS .010 MAX. R

1. TAG IDENT PART NO. & SERIAL NO. PER P294517-1 SEE IDENT COLUMN

QTY. REQD	SYM	ITEM NO.	NOMENCLATURE OR DESCRIPTION	PART OR IDENTIFYING NO.	MATERIAL	SPECIFICATION	ZONE
1		1	TUBE	615B711H01-	OFHC CU	QQ-C-576	

LIST OF MATERIALS

CONTRACT NO.	
DFTM. H.K.	DATE OF DWG. 7-26-73
CHECKER D. Rennie 8/7/73	RELIAB. & Q. A.
DESIGN	MFG.
ANALYSIS	
MATL.	DFT. SUPV.

2PL. DEC	3PL. DEC	ANGLES	125 ✓ AA
±.02	±.005	±0°30'	

P294517-1	IDENT	DWG. CODE NO.	2
SPECIFICATION	TYPE		
L/O NO.	PCN		

INFORMATION CATEGORY N.A.

AUTHORIZED CLASSIFIER DATE

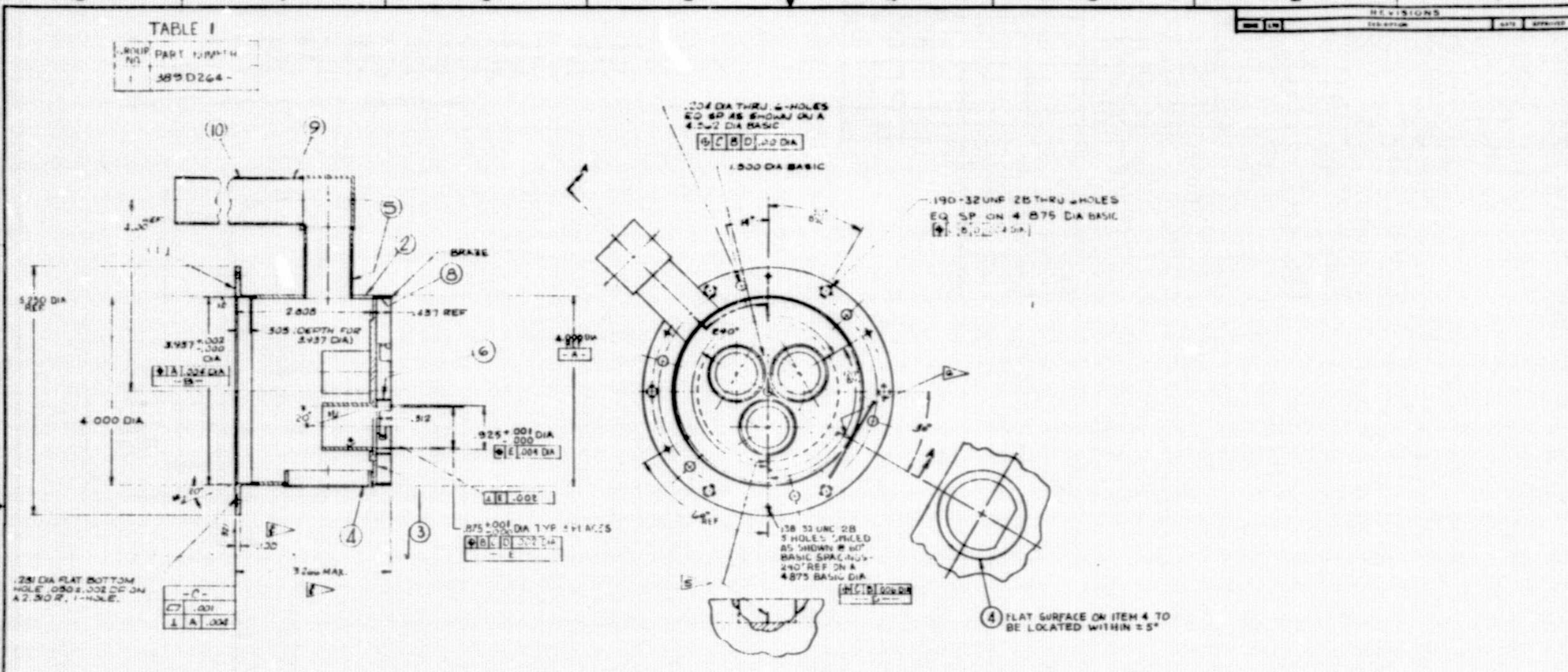
Westinghouse Astronuclear Laboratory
Pittsburgh, Pennsylvania

HEAT TRANSFER TUBE
FURNACE CHAMBER
MULTIPURPOSE ELECTRIC FURNACE SYSTEM

DWG SIZE	CODE IDENT NO.	DWG. NO.
B	14683	615B711

SCALE 2:1 | WT ACT ~ | WT CALC ~ | SHEET 1 OF 1

615B711



QTY		ITEM NO	NOMENCLATURE OR DESCRIPTION	CODE IDENT NO	PART OR IDENTIFYING NO	MATERIAL	SPECIFICATION	ZONE
1		10	TUBE		389D186H06-			
1		9	90° ELBOW		389D186H08-			
1		8	RING		101E430H12E			
AR	6	7	PAINT - WHITE		16MG1843	PAINT		
3		6	ACCESS PORT		101E430H09B			
1		5	TUBE		389D186H07-			
1		4	BOSS, RECEPTACLE		101E430H11-			
1		3	CAP		101E430H02B			
1		2	TUBE		800C850H01-			
1		1	FLANGE		101E430H07A			

PARTS LIST

6 R.O. FROM MSFC

5 THESE ARE INTERFACE CONTROL DIMENSIONS AND CANNOT BE CHANGED WITHOUT PRIOR APPROVAL OF PROGRAM MANAGER.

5 ORIENT ITEM 2 & ITEM 3 AS SHOWN & MATCH SCRIBE LINES ON ITEMS 3 & 6 AND 2 & 3 BEFORE BRAZING.

4- COPPER FURNACE BRAZE ALL JOINTS VACUUM TIGHT PER P597994-1.

3- UNLESS OTHERWISE SPECIFIED FEATURES SHOWN COAXIAL TO DATUM -A- ARE .006 DIA

2- TAG PART NUMBER AND SERIAL NUMBER PER P294517-1, SEE IDENT COL.

1- UNLESS OTHERWISE SPECIFIED, REMOVE ALL BURRS & BREAK ALL SHARP EDGES .010 MAX R OR CHAMFER. INTERNAL CORNERS .010 R MAX.

UNLESS OTHERWISE SPECIFIED
INTERPRET DWG PER MIL-D-1000
TOLERANCES - DO NOT SCALE
2PL DEC | 3PL DEC | ANGLES

P294520-1 CLEANING

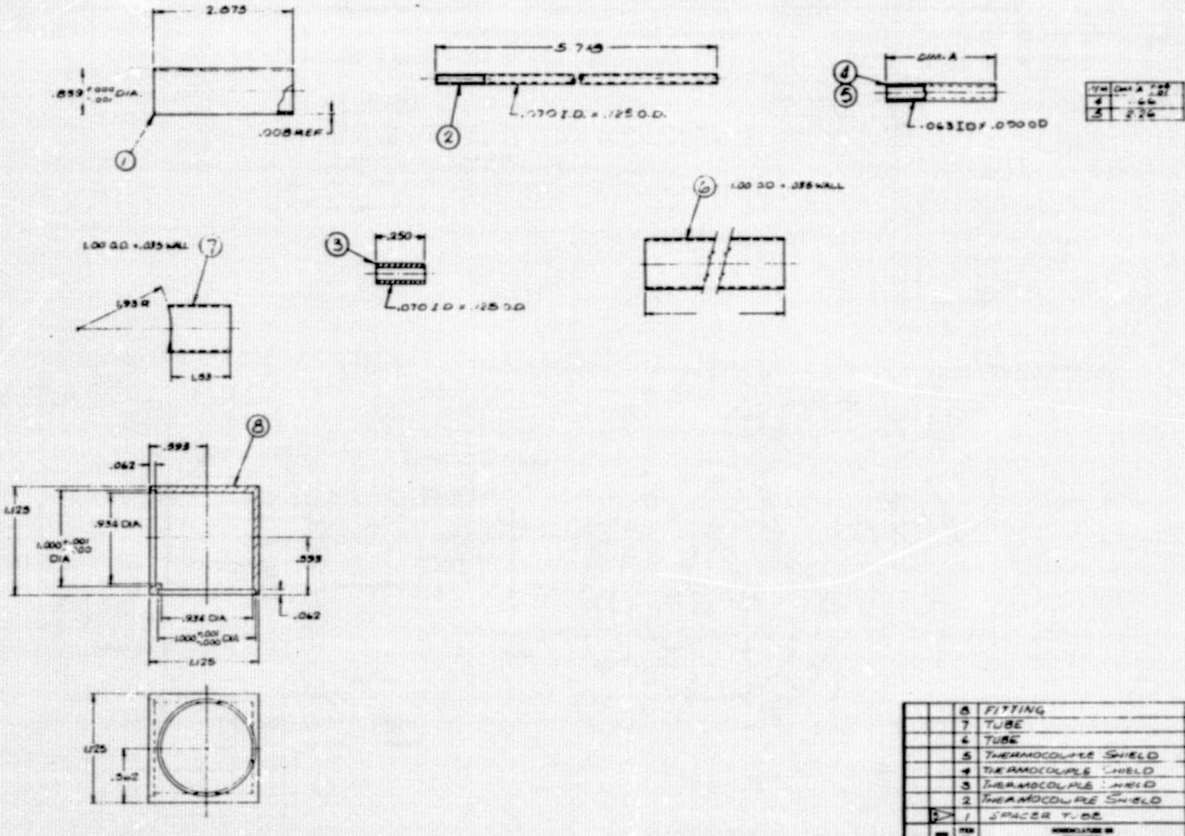
NEXT ASSY | USED ON
APPLICATION
DWG CODE NO.

INFORMATION CATEGORY

Westinghouse Astronuclear Laboratory
Pittsburgh, Pennsylvania

CHAMBER ASSY FURNACE SYS.

D | 14683 | 389D264



ITEM	DIM. A
4	.66
5	2.26

		8	FITTING		389D186H08	SST		
		7	TUBE		389D186H07	SST		
		6	TUBE		389D186H06			
		5	THERMOCOUPLE SHIELD		389D186H05	TEFLON		
		4	THERMOCOUPLE SHIELD		389D186H04	TEFLON		
		3	THERMOCOUPLE SHIELD		389D186H03	ALUMINA		
		2	THERMOCOUPLE SHIELD		389D186H02	ALUMINA		
	3	1	SPACER TUBE		389[illegible]	[illegible]	[illegible]	
QTY REQD	SYM	ITEM NO	NOMENCLATURE OR DESCRIPTION	CODE IDENT NO	PART OR IDENTIFYING NO	MATERIAL	SPECIFICATION	ZONE

PARTS LIST

3 MAKE FROM .875 O.D. x .016 WALL TUBE.

2 UNLESS OTHERWISE SPECIFIED, REMOVE ALL BURRS & BREAK ALL SHARP EDGES .010 MAX RADIUS OR CHAMFER. INTERNAL CORNERS .010 MAX R.

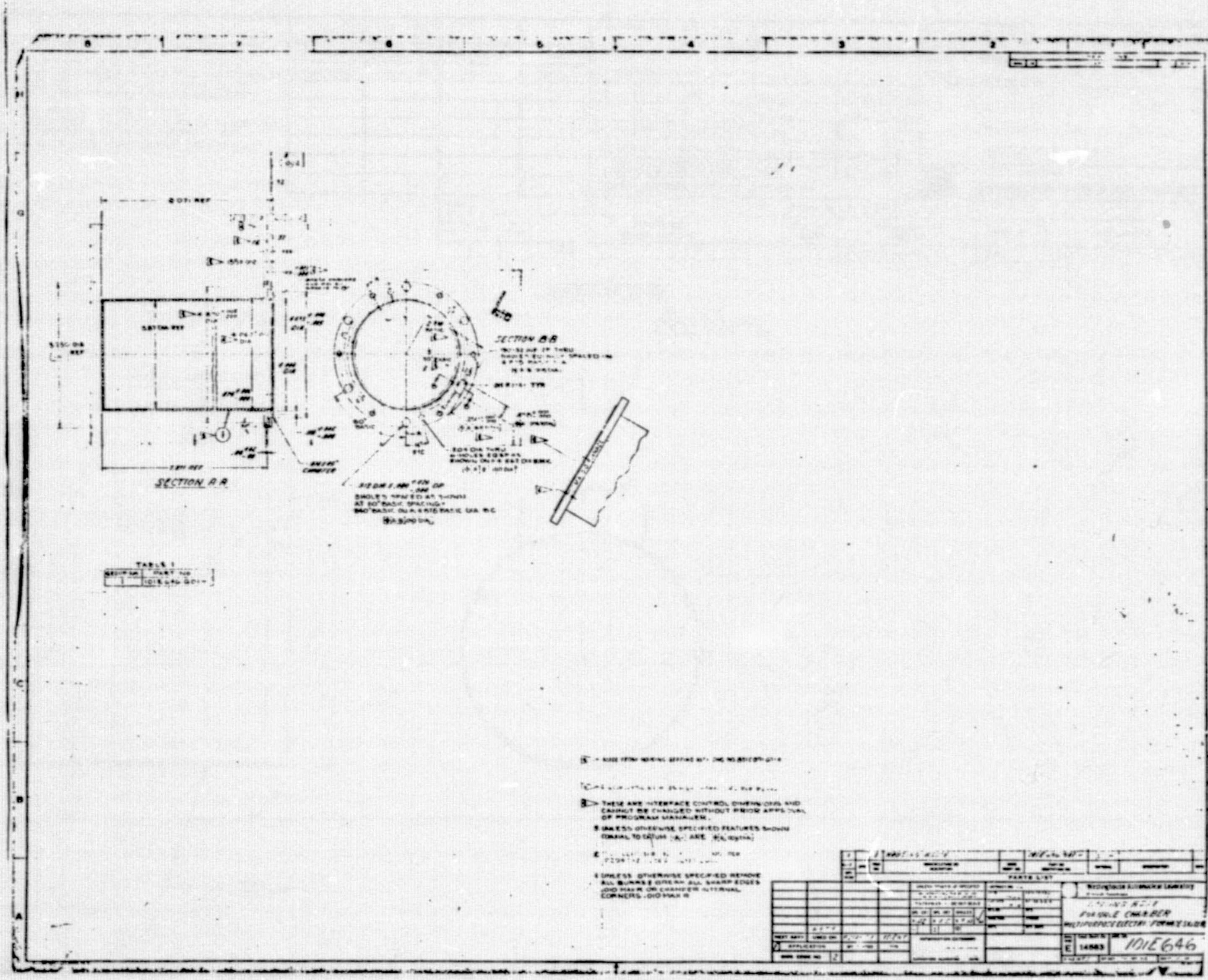
1. TAG IDENT PART NO. & SERIAL NO PER P-294517-1. SEE IDENT COL.

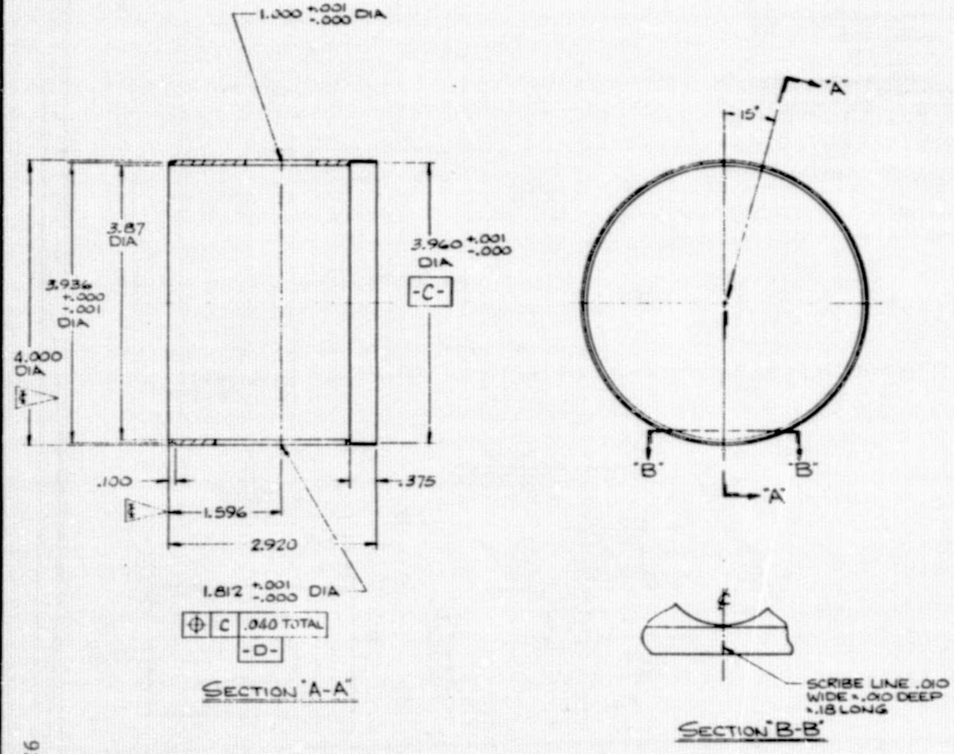
UNLESS OTHERWISE SPECIFIED
INTERPRET DWG PER MIL-D-1000 DIM IN INCHES BASED ON ##
TOLERANCES — DO NOT SCALE

Westinghouse Astronuclear Laboratory

NEXT ASSY | USED ON
APPLICATION
DWG CODE NO.
INFORMATION CATEGORY
AUTHORIZED CLASSIFIER DATE

D 14683


SECTION A-A
SECTION B-B
TABLE 1
THESE ARE INTERFACE CONTROL DIMENSIONS AND CANNOT BE CHANGED WITHOUT PRIOR APPROVAL OF PROGRAM MANAGER.
UNLESS OTHERWISE SPECIFIED FEATURES SHOWN COAXIAL TO DATUM
UNLESS OTHERWISE SPECIFIED REMOVE ALL BURRS & BREAK ALL SHARP EDGES .010 MAX R OR CHAMFER INTERNAL CORNERS .010 MAX R
PARTS LIST
CHAMBER
14583
101E646



ZONE	LTR	DESCRIPTION	DATE	APPROVED

REVISIONS

THESE ARE INTERFACE CONTROL DIMENSIONS AND CANNOT BE CHANGED WITHOUT PRIOR APPROVAL OF PROJECT MANAGER.

2- UNLESS OTHERWISE SPECIFIED, REMOVE ALL BURRS & BREAK ALL SHARP EDGES .010 MAX R OR CHAMFER INTERNAL CORNERS .010 MAX R.

1- TAG IDENT PART NO. & SERIAL NO. PER P294517-1, SEE IDENT COLUMN.

G01		1	TUBE		800C890H01-	SST	ASTM A269 SMLS (304)	
QTY REQD	SYM	ITEM NO.	NOMENCLATURE OR DESCRIPTION	CODE IDENT NO.	PART OR IDENTIFYING NO.	MATERIAL	SPECIFICATION	ZONE

PARTS LIST

NEXT ASSY	USED ON	P294517-1	IDENT
5 APPLICATION		SPECIFICATION	TYPE
DWG CODE NO. 2			

UNLESS OTHERWISE SPECIFIED

INTERPRET DWG PER MIL-D-1000 DIM IN INCHES BASED ON 68°F

TOLERANCES — DO NOT SCALE

2PL DEC	3PL DEC	ANGLES	
±.02	±.005	±0°30'	125 AA

INFORMATION CATEGORY N.A.

AUTHORIZED CLASSIFIER / DATE

CONTRACT NO.	
DFTM M. VONSIK	DATE OF DWG 2-13-74
CHECKER 2-15-74 W. SUMMERMAN	RELIAB & Q. A.
DESIGN	MFG
ANALYSIS	STRESS
MATL	OPT SUPV

Westinghouse Astronuclear Laboratory
Pittsburgh, Pennsylvania

HOUSING TUBE
FURNACE CHAMBER
MULTIPURPOSE ELECTRIC FURNACE SYSTEM

DWG SIZE	CODE IDENT NO.	DWG NO
C	14683	800 C 890

SCALE FULL | WT ACT — | WT CALC — | SHEET 1 OF 1

800C890

APPENDIX B — VACUUM LINE TEST DATA

The following graphs illustrate the performance of a variety of pump line configurations. In all cases, the pump line terminated in a vacuum bell jar maintained at a pressure of about 10^{-5} torr. The pressure scale on all the graphs refers to the pressure in the furnace.

Curve 1 in Fig. B-1 illustrates pumping performance with a section of 3/8" O.D. tubing in the pump line. This is clearly unsatisfactory. Replacing the 3/8" line with 3/4" O.D. line improves the pump line performance substantially. The effects of furnace outgassing become quite clear when these curves are compared with Curve 3, which is an almost vertical line on the left side of the graph. Curve 3 illustrates the performance of the 3/4" configuration when the preconditioned furnace has been maintained with a helium atmosphere and not opened to the air before pump down.

The data in Fig. B-2 corresponds to the 3/4" pump line configuration with a 21/64" x 1-1/2" long constriction placed in the line. Curve 4 dramatically illustrates the multiple outgassing bursts during furnace heat-up.

Figures B-3 through B-7 illustrate the results of a series of five consecutive runs using a detailed equivalent of the 1" DM pump line. The dotted curves denote pressure and the solid curves denote heat leveler temperature. In all cases, except run 4, the furnace was opened to the atmosphere for 5 minutes immediately preceeding the pump down. The 3/8" constriction is a simple orifice in a thin plate, and has no noticeable effect on the pump line performance. What is

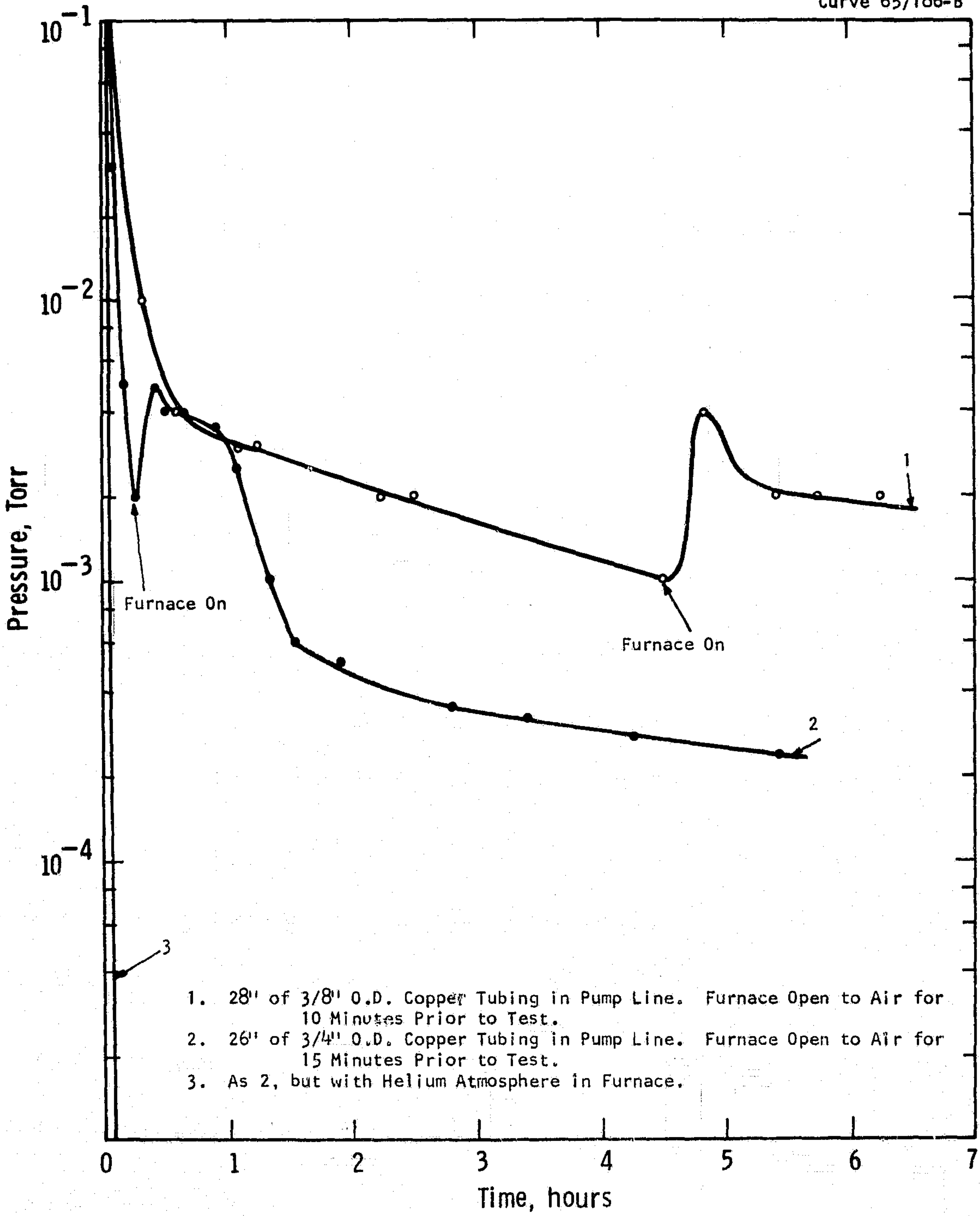


Fig. B-1—Furnace pump down rates under various conditions

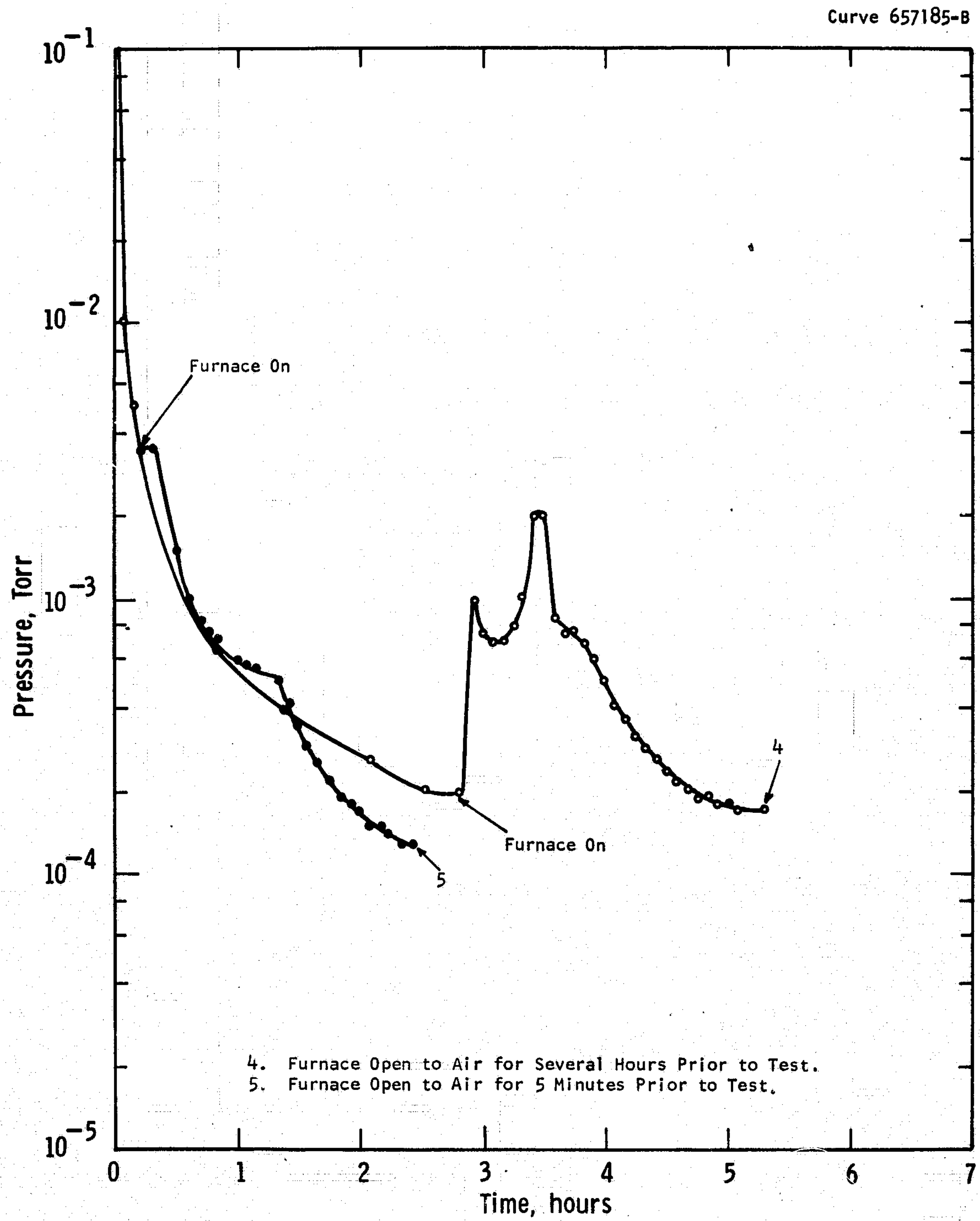


Fig. B-2—Furnace pump down rates with 2/164" diameter × 1 1/2" long constriction in 3/4" O. D. pump line.

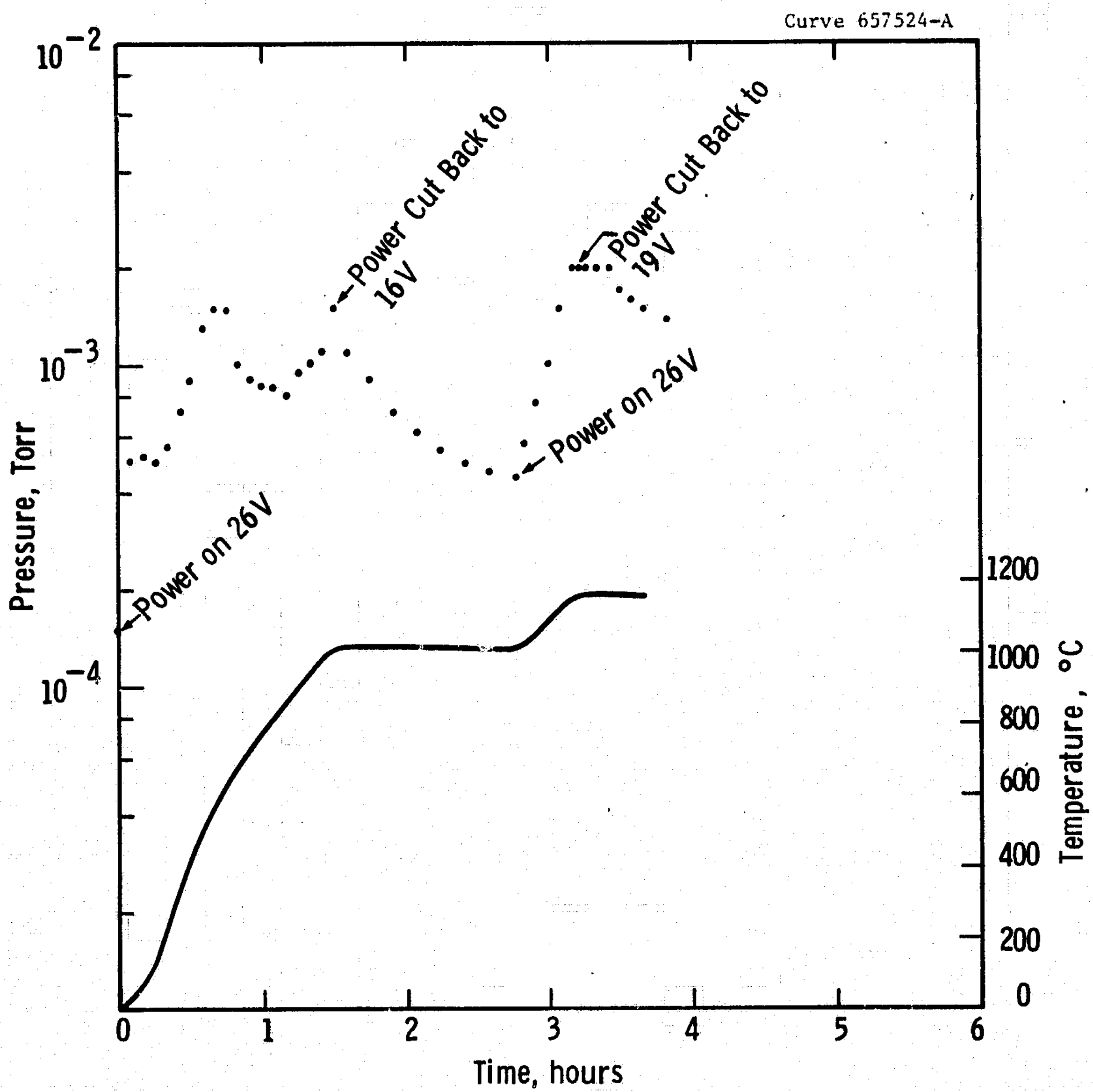


Fig. B-3—Run 1, 3/8" constriction in pump line

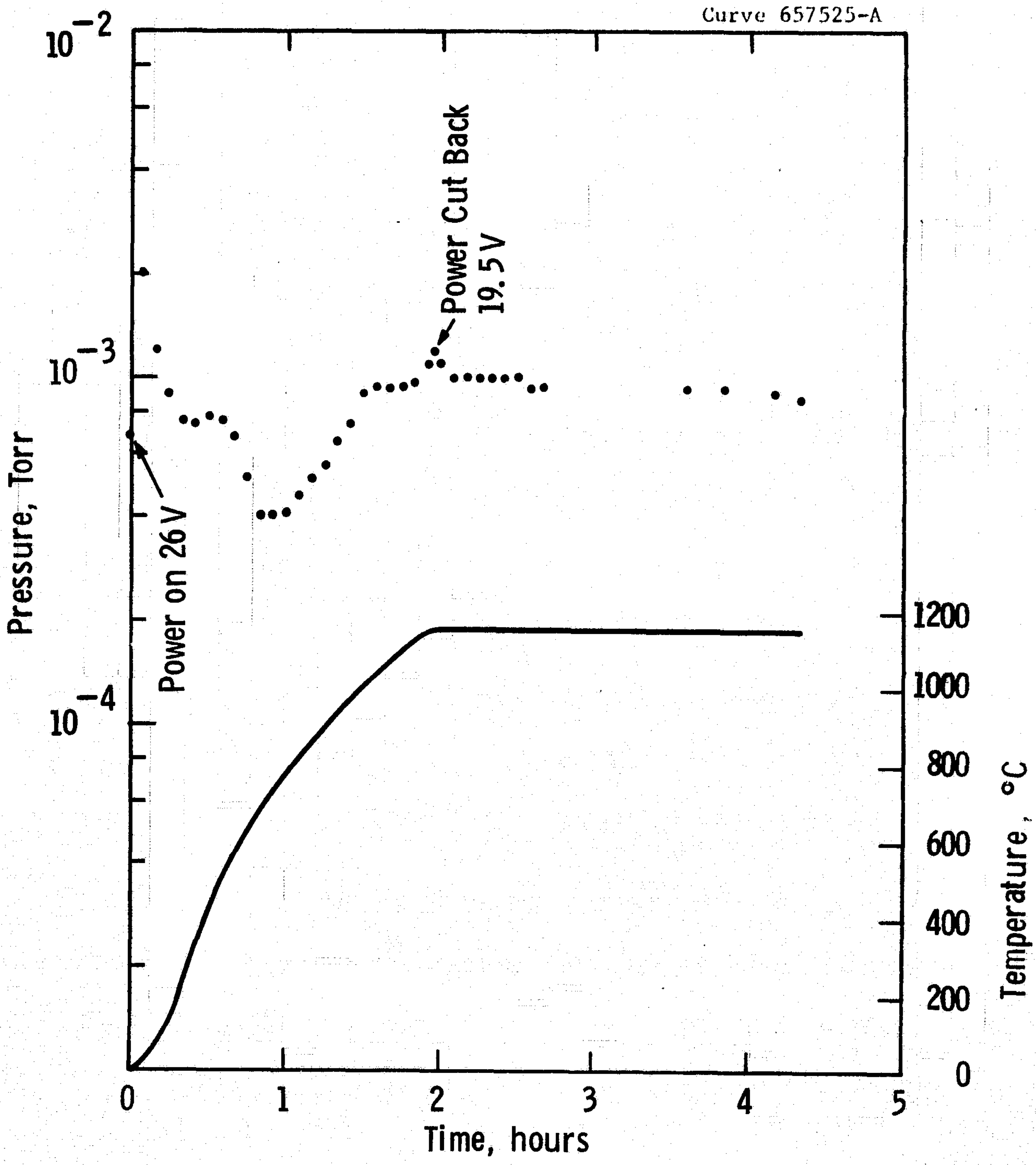


Fig. B-4—Run 2, without 3/8" constriction in pump line

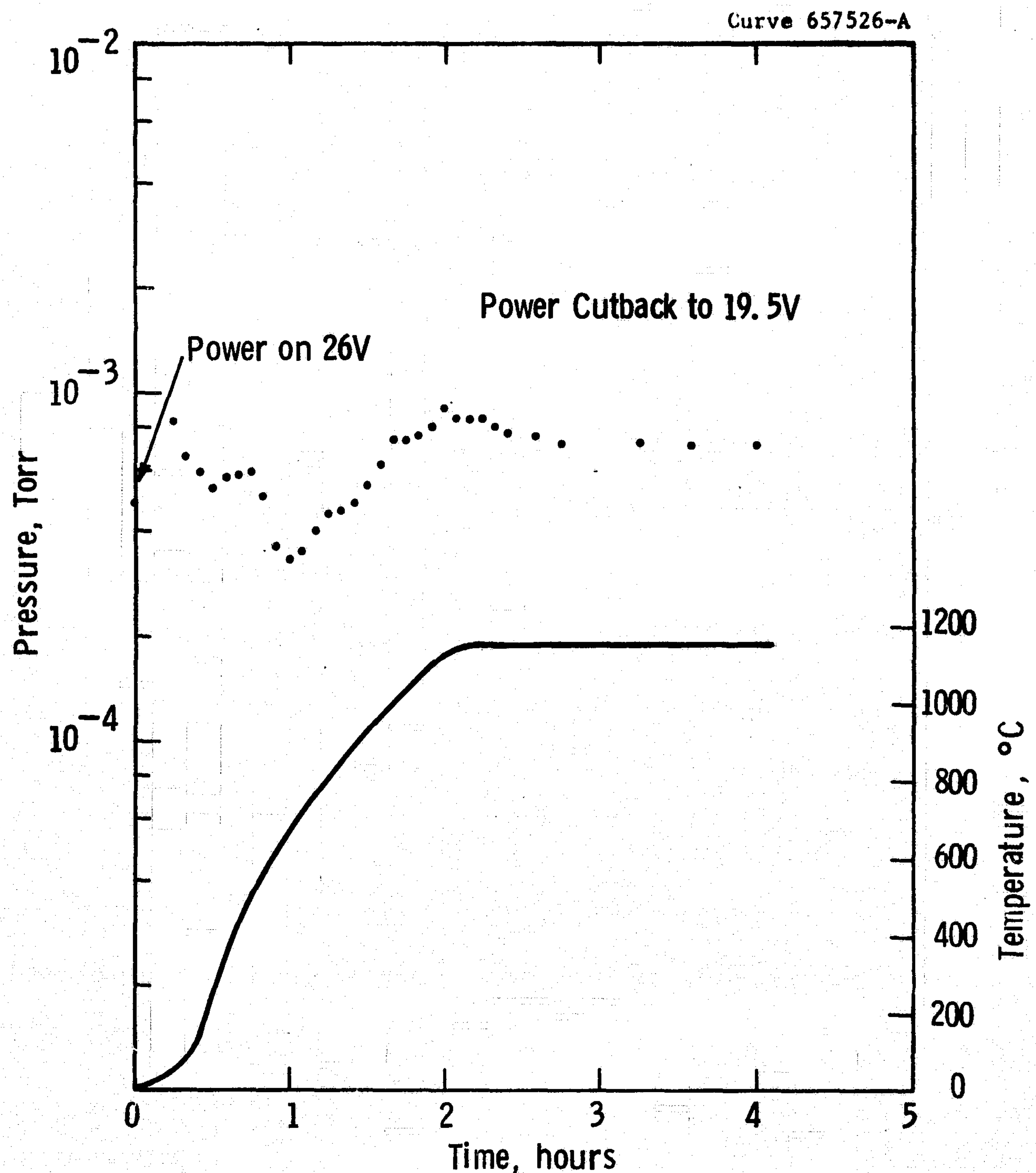


Fig. B-5—Run 3, 3/8" constriction in pump line

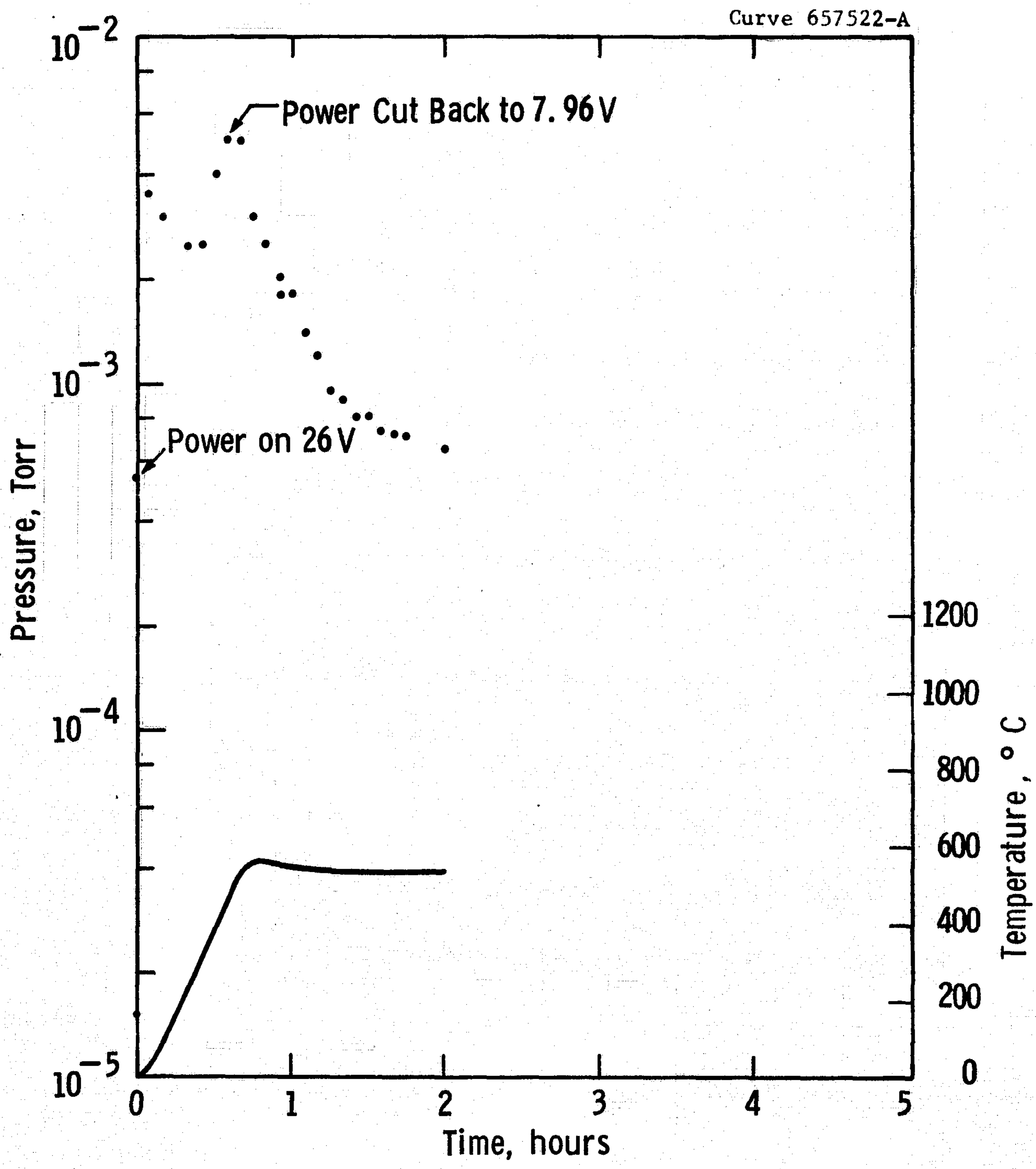


Fig. B-6—Run 4, 3/8" constriction in pump line, after opening furnace to air for 20 hours

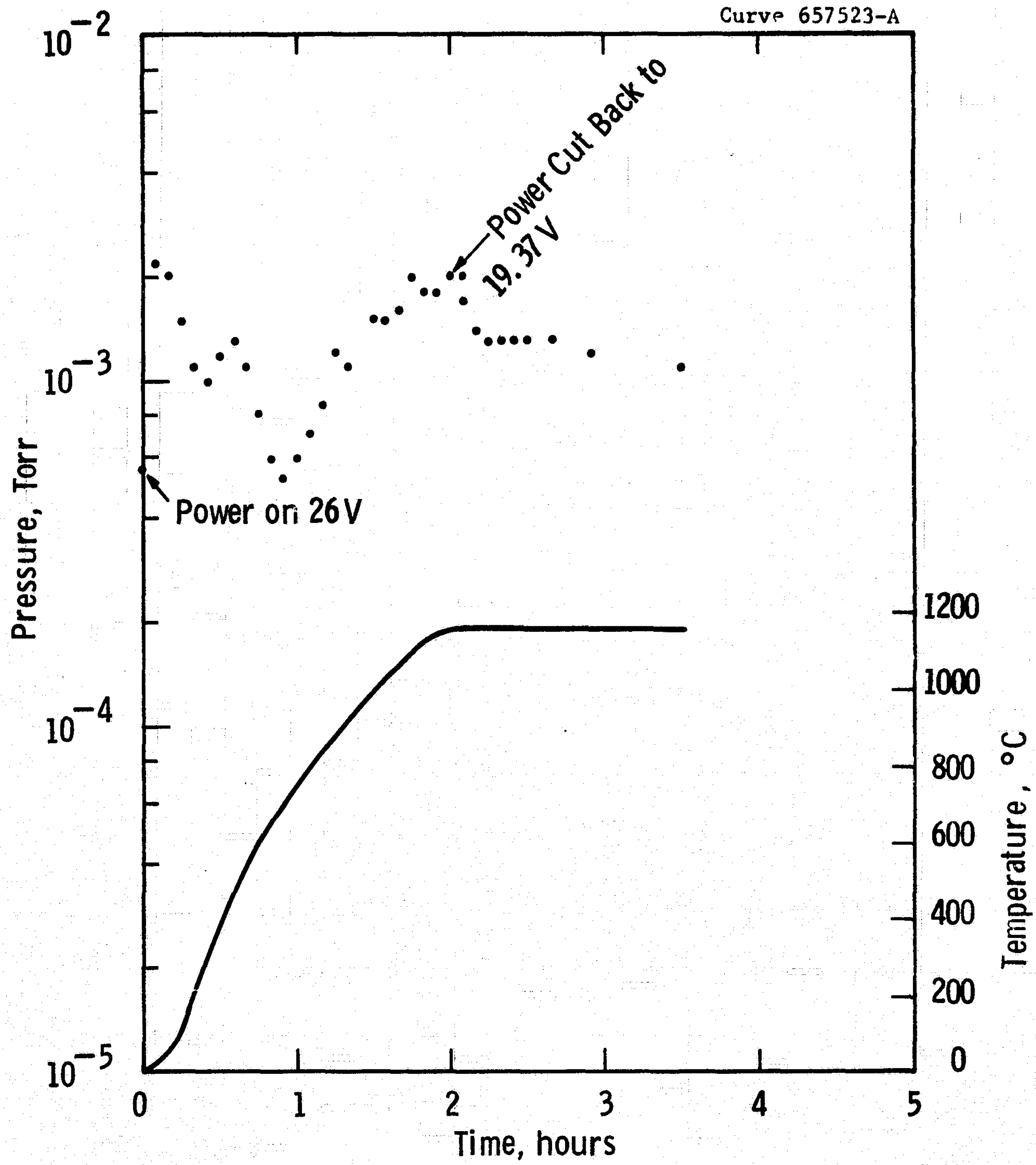


Fig. B-7—Run 5, 3/8" constriction in pump line

more pronounced is the gradual improvement in vacuum as the furnace is conditioned with three consecutive high temperature runs (Figs. B-3, B-4 and B-5). After run 3, the furnace was left open to the atmosphere for 20 hours. Run 4, Fig. B-6, is a preconditioning run. This was followed by run 5. Note in all cases the multiple outgassing bursts during heat-up. Figure B-5 demonstrates the performance with maximum pre-conditioning and Fig. B-7 shows the performance with minimum pre-conditioning.

APPENDIX C -- CONCEPTUAL CARTRIDGE DESIGNS

As an addendum to the principal task of this contract, preliminary conceptual designs were to be developed for certain of the experiment cartridges.

Of the six original experiments chosen for the Multipurpose Furnace on the ASTP mission, three apparently require cartridges very similar to cartridges used for experiments in the M518 series of experiments of Skylab. Three of the experiments, however, apparently required somewhat more complex designs. In order to clarify the requirements for these experiments in more detail than was available from the proposals, a meeting was arranged by NASA between the principal investigators, Westinghouse, and MSFC personnel. The objectives of the experiments were discussed in detail and the general requirements for the experiment cartridges were agreed on. At this stage of the program, however, detailed requirements were not determined (e.g. exact material composition, precise ampoule dimensions, etc.). As a result of this conference, Westinghouse was directed by MSFC, as an additional task on the present program, to develop conceptual designs for possible experiment cartridges for the three experiments. The following figures and discussions represent these conceptual designs.

While the designs themselves should illustrate the general configuration of the cartridges, they should not be construed to be accurate assembly drawings. Many mechanical details such as the latching and sealing mechanisms depend on design decisions yet to be made on the Multipurpose Furnace itself. Specific thermal design requires more effort than was intended for this task. Nevertheless, while the final cartridge designs may differ in detail from those presented here, they will probably depart but little in general configuration.